INSTRUCTIONS

MODEL 618B

SHF SIGNAL GENERATOR

Specifications

Frequency Rating --

Frequency Range - 3600 to 7600 megacycles.

Frequency Calibration Accuracy - Better than ±1%.

Frequency Stability - .006% per degree Centigrade of change in ambient temperature from -20°C to + 40°C. Line voltage variations of ±10% from 115 volts cause less than .02% change in frequency.

Output Rating --

Maximum Output Power - 1 milli~~watt~~ Volts into 52 ohms.

Output Power Range - 223 milli~~watts~~ Volts (0 dbm) to .1 microvolt (-127 dbm). Attenuator continuously variable and directly calibrated in millivolts, microvolts, decibels. Attenuator accuracy within ±2%.

Output Impedance - 52 ohms nominal (VSWR less than 2).

Types of Output -

Unmodulated (CW).

Internal Pulse Modulation - Repetition rate variable from 40 to 4000 pulses/sec. Pulse length variable from .5 to 10 microseconds as measured between points that are 50% of the maximum amplitude of the initial rise. The combined rise and decay time does not exceed .5 microseconds.

External Pulse Modulation - External pulse modulation requires pulses having the following characteristics.

Amplitude - 15 to 70 volts

Width - .5 to 2500 microseconds

Separation - 1 to 2500 microseconds

Polarity - Positive or negative

Rise Time - .1 to 1 microsecond

Decay Time - .1 to 1 microsecond

Internal Frequency Modulation - The saw-tooth sweep rate is variable from 40 to 4000 cycles/sec. The frequency deviation is variable from 0 to ±3 megacycles.

External Frequency Modulation - With a sine wave input frequency deviation up to 10 megacycles can be obtained depending on the frequency of the radio frequency oscillator.

Internal Square Wave Modulation - variable from 40 to 4,000 cycles/sec.

External Square Wave Modulation - Externally generated square wave of at least 15 volts amplitude and a frequency of 40 to 20,000 cycles/sec.

Sync Out Signals -

a. (Delayed Sync Out) - A positive pulse simultaneous with the front of the radio frequency pulse. Pulse amplitude at least 25 volts and rise time shorter than one microsecond. The output circuit is designed to work into a load of 1000 ohms or more shunted by not more than 50 μμf capacity.

b. (Undelayed) - Has the same characteristics as the number 1 sync out signal except that the pulse precedes the front of the radio frequency pulse by 3 to 300 micro-seconds.

<u>External Synchronization</u> -

Both the pulse and frequency modulated radio frequency output may be synchronized with the following externally generated signals.

1. Sine waves of 40 to 4,000 cycles/sec. and 5 to 50 volts (RMS) amplitud

2. Pulses of 40 to 4,000 pulses/sec., a peak amplitude of 5 to 50 volts, a rise time of .1 to 1 microsecond, and a width of .5 to 5 microsecon

<u>Power Supply Rating</u> --

Voltage - 115 volts ±10%

Frequency - 50/60 cycles/sec.

Wattage - 250 watts

SECTION II

OPERATING PROCEDURES

KEY TO FIGURE 2-1

1.	ON SWITCH	14.	PULSE WIDTH control
2.	POWER indicator	15.	PULSE DELAY control
3.	HEATER indicator	16.	PULSE RATE control
4.	SIGNAL FREQUENCY control	17.	SYNC SELECTOR switch
5.	MEGACYCLES dial	18.	Control locks
6.	ZERO SET control	19.	RF OUTPUT connector
7.	POWER SET control	20.	EXT MOD connector
8.	POWER SET meter	21.	SYNC IN connector
9.	Attenuator dial index	22.	SYNC OUT connector
10.	OUTPUT ATTEN control	23.	DELAYED SYNC OUT connector
11.	OUTPUT ATTEN dial	24.	POWER INPUT connector
12.	FM AMPLITUDE control	25.	Line fuseholders
13.	MOD SELECTOR switch	26.	Spare fuseholders

f. The HEATER indicator light on the front panel should be on, indicating that electrical power is being supplied to the input connector of the signal generator.

g. Place the RF Power Cable CG-92D/U (6'0") on the RF OUTPUT connector.

2-3. WARMING UP THE EQUIPMENT

Place the ON switch in its up position and the MOD. SELECTOR switch in the CW position. The HEATER indicator light on the front panel should go out and the POWER indicator light should come on. After approximately 90 seconds, the POWER SET meter should begin to move. Check the warm-up period as follows:

a. Place the MOD. SELECTOR switch in the OFF position. Adjust the ZERO SET control so that the needle of the meter is in the ZERO SET position.

b. Return the MOD. SELECTOR switch to the CW position. Adjust the POWER SET control until the needle of the meter rests on the red line at the center of the scale.

c. Allow the equipment to stand for approximately 10 minutes with power on.

d. Repeat steps a and b above.

2-4. OPERATING CONTROLS (See figure 2-1.)

The operating controls of Signal Generator TS-621/U are shown in figure 2-1. They are all located on the front panel. The operating controls and a description of their functions follows:

a. ON switch (1). When this switch is in the ON (up) position, power is applied to the electronic circuits of the signal generator. When it is in its downward position, power is applied only to the space heaters in the instrument which maintain the internal temperature a few degrees above ambient.

b. POWER indicator (2). When this indicator is on, power is applied to the electronic circuits of the signal generator.

c. HEATER indicator (3). When this indicator is on, power is applied to the heaters and removed from the electronic circuits.

d. SIGNAL FREQUENCY control (4). This control is used to adjust the operating frequency of the shf oscillator to the desired output frequency. The frequency is read on the MEGACYCLES dial (5) above the control. A 360° vernier scale graduated from 0 to 100 is provided on the control itself so that accurate re-setting to a specific frequency can be made.

e. ZERO SET control (6). This control is used to set the needle of the POWER SET meter (8) to the zero position when the MOD. SELECTOR switch is in the OFF position and the power switch is in the ON position.

f. POWER SET control (7). This control is used to set the needle of the POWER SET meter (8) to 0 db (red line at center of scale) prior to adjusting the attenuation. It also operates the fiducial (9) over the OUTPUT ATTEN (attenuator) dial to establish the reference level for reading the attenuator dial.

g. OUTPUT ATTEN (attenuator control (10). This control determines the attenuation of the radio frequency output of the signal generator. It also operates the OUTPUT ATTEN dial (11) so that the reading of this dial under the index indicates the output level of the signal generator in voltage and in decibels below one milliwatt.

h. FM AMPLITUDE control (12). This control adjusts the deviation (frequency swing) of the output frequency from 0 to ± 3 megacycles from the center (CW) frequency when frequency modulation is employed.

i. MOD SELECTOR switch (13). This switch is located in the upper left hand corner of the front panel of the signal generator. It has the following positions:

   1. EXT FM. When in this position, the signal generator circuits are switched so that an external sine or sawtooth voltage may be applied to the EXT. MOD input connector (20) to provide externally modulated output.

2. INT FM. When in this position, the signal generator circuits are switched so that sawtooth type frequency-modulated pulses are provided. When the SYNC SELECTOR switch (17) is in the X1 or X10 position, these pulses are initiated by the internal pulse generating circuits of the signal generator.

3. CW. When in this position, the output of the signal generator is continuous wave.

4. OFF. When in the OFF position, the r-f oscillator tube is biased off so that the signal generator will provide no output. This position is provided to permit the POWER SET meter to be zero set before each test by adjustment of the ZERO SET control (see paragraph 2-4e). However, filament and plate voltages remain applied to all tubes so that the signal generator may be instantly operative when this switch is moved to one of its other positions.

5. INT. When in this position the pulse repetition frequency is indicated by the position of the PULSE RATE control (16) when the SYNC SELECTOR switch (17) is in the X1 position. When the SYNC SEL switch is in the X10 position, the pulse rate will be 10 times the rate indicated by the calibrations of the PULSE RATE control.

6. EXT +. When in this position, the signal generator may be modulated by positive external pulses or square waves applied to the EXT MOD connector (20) on the front panel.

7. EXT -. When in this position, the signal generator may be modulated by negative external pulses or square waves applied to the EXT MOD connector (20) on the front panel.

8. SQ WAVE. When in the SQ WAVE position the output of the signal generator will be square waves of radio frequency voltage. The repetition rate of these pulses will be determined by the adjustment of the PULSE RATE control (16) and the SYNC SELECTOR switch in the X1 or X10 position and will be between 40 and 4,000 pulses per second. The "on" time will be approximately equal to the "off" time.

2. INT TR. When in this position, the signal generator circuits are adjusted so that switch-type frequency-modulated pulses are provided. When the SYNC SELECTOR switch (17) is in the X1 or X10 position, timer pulses are initiated by the internal pulse generating circuits of the signal generator.

3. TR. When in this position, the output of the signal generator is continuous wave.

4. OFF. When in the OFF position, the rel oscillator tube is biased off so that the signal generator will provide no output. This position is provided to permit the ZERO SET meter to be zeroed and to set the meter (test by adjustment of the ZERO SET control (see paragraph 4-4a)). However, filament and plate voltages remain applied to all tubes so that the signal generator may be instantly operating when this switch is moved to one of its other positions.

5. INT. When in this position the pulse repetition frequency is indicated by the position of the PULSE RATE control (16) when the SYNC SELECTOR switch (17) is in the X1 position. When the SYNC SEL switch is in the X10 position, the pulse rate will be 10 times the rate indicated by the calibrations of the PULSE RATE control.

6. EXT +. When in this position, the signal generator can be modulated by positive external pulses or square waves applied to the EXT MOD connector (20) on the front panel.

7. EXT -. When in this position, the signal generator can be modulated by negative external pulses or square waves applied to the EXT MOD connector (20) on the front panel.

8. SQ WAVE. When in the SQ WAVE position the output of the signal generator will be square waves of radio frequency voltage. The repetition rate of these pulses will be determined by the adjustment of the PULSE RATE control (16) and the SYNC SELECTOR switch in the X1 or X10 position and will be between 20 and 4,000 pulses per second. The "on" time will be approximately equal to the "off" time.

j. PULSE WIDTH control (14). The adjustment of this calibrated control determines the width of the main output pulse when the MOD SELECTOR switch (13) is in the INT position and the SYNC switch is in the EXT +, EXT-, ∼ , X1 or X10 positions. The width is between approximately 0.5 (MIN) and 10 microseconds, depending on the position of the control.

k. PULSE DELAY control (15). This control determines the time delay between the start of the synchronizing pulse and the start of the radio frequency output pulse delivered by the signal generator. The control permits the insertion of delays from 3 to 300 microseconds following the synchronizing pulse. This same delay period will also be present between the pulse appearing on the SYNC OUT connector (22) and the DELAYED SYNC OUT connector (23) on the control panel.

l. PULSE RATE control (16). The setting of this control determines the pulse repetition frequency of the internal pulse generating circuits when the MOD SELECTOR switch (13) is in the INT, INT FM or SQ WAVE position and the SYNC SELECTOR switch (17) is in either the X1 or the X10 position. When the SYNC SELECTOR switch is in the X1 position, the pulse repetition rate is as read on the calibrated dial of the control. When the SYNC SELECTOR switch is in the X10 position, the reading of the pulse rate control must be multiplied by 10 to indicate pulse repetition rate.

m. SYNC SELECTOR switch (17). This switch determines the type of synchronization that is to be employed by the signal generator. It has the following positions:

1. ∼. When the switch is in this position, and the MOD SELECTOR switch (13) is in the INT position, the signal generator may be synchronized by external sine wave voltages with an amplitude between 5 and 50 volts rms, applied to the SYNC IN connector (21) on the front panel.

2. EXT-. When the switch is in this position, and the MOD SELECTOR switch (13) is in the INT position, the signal generator must be synchronized by external negative voltage pulses of an amplitude between 5 and 50 volts applied to the SYNC IN connector (21) on the front panel.

3. EXT+. When the switch is in this position, and the MOD SELECTOR switch (13) is in the INT position, the signal generator must be synchronized by external positive voltage pulses with an amplitude of between 5 and 50 volts applied to the SYNC IN connector (21) on the front panel.

4. X1. When the SYNC SEL switch is in this position and the MOD SELECTOR switch (13) is in the INT position, the internal pulse generator is free-running. The repetition rate is as read directly on the PULSE RATE control (16).

5. X10. When the SYNC SELECTOR switch is in this position and the MOD SELECTOR SWITCH (13) is in the INT position, the repetition rate of the synchronizing pulses is as read on the dial of the PULSE RATE control (16) multiplied by 10.

2-5. STEP-BY-STEP OPERATING PROCEDURE

Operating this instrument can be divided into two parts: adjusting the r-f section and adjusting the modulator section. In general, it is desirable first to adjust the r-f section, since this adjustment establishes the reference levels for the output power-monitoring system. The following procedures are recommended.

2-6. POWER CONNECTION

Connect the power plug to a nominal 115-volt, 50 to 1000 cps, single phase power source and turn on the power switch. Allow the instrument to heat for a minimum of five minutes. If ambient temperature is below about 10° C (50° F), a longer warm-up period is desirable.

2-7. TO ADJUST THE R-F SECTION AND TO OBTAIN CW OUTPUT

(See figure 2-1.)

a. Tune the signal generator to the desired frequency with the SIGNAL FREQUENCY control (4).

b. Set MOD SELECTOR switch (13) to OFF position and adjust ZERO SET control (6) so that POWER SET meter needle (8) is exactly over the ZERO SET index line on the meter.

c. Place MOD SELECTOR switch (13) to the CW position.

d. Adjust POWER SET meter (8) to zero dbm position by means of the POWER SET control (7)

e. Adjust the OUTPUT ATTEN control (10) to the desired value of attenuation as indicated by the OUTPUT ATTEN dial (11) under the index.

f. The above adjustments determine the frequency of the r-f output of the signal generator and the output power level in decibels below one milliwatt (0.228 volt) when working into the rated load of 52 ohms.

NOTE: For a given setting of the OUTPUT ATTENUATOR dial, the indicated peak voltage of the r-f output under conditions other than CW will be within $\pm$ 1 decibel of that for CW operation.

2-8. TO OBTAIN MODULATED OUTPUT

The signal generator, for the purpose of the following adjustments, is assumed to be warmed up and calibrated in accordance with paragraph 2-7. The following paragraphs outline the adjustment of the controls and the connections of the cables in order to obtain various types of modulated output.

2-9. SQUARE WAVE OUTPUT (See figure 2-1.)

a. Set MOD SELECTOR switch (13) to SQ WAVE position.

b. Set SYNC SELECTOR switch (17) to the X1 or X10 position and set PULSE RATE control (16) as necessary to obtain desired repetition rate.

c. Connect the r-f cable between RF OUTPUT connector (19) on signal generator and equipment being tested.

d. A sync pulse is available at the SYNC OUT connector for each cycle of square wave.

2-10. INTERNAL PULSE MODULATION (See figure 2-1.)

a. Set MOD SELECTOR switch (13) to INT position.

b. Set SYNC SELECTOR switch (17) to X1 or X10 and set PULSE RATE control (16) as necessary to obtain desired pulse repetition rate.

c. Set PULSE WIDTH control (14) to a position between 0.5 (MIN) and 10 microseconds as desired.

d. Set PULSE DELAY control (15) to obtain desired delay.

e. Set FM AMPLITUDE control (12) to OFF position.

f. Connect r-f cable between RF OUTPUT connector (19) and load.

g. Connect video cable between the SYNC OUT and/or DELAYED SYNC OUT connectors and external equipment as required by the application.

2-11. INTERNAL FREQUENCY MODULATION (Sawtooth)

a. Set MOD SELECTOR switch (13) to INT FM position.

b. Set the SYNC SELECTOR switch (17) to X1 or X10 position and set PULSE RATE control (16) so that desired repetition frequency will be obtained.

c. Set FM AMPLITUDE control (12) to OFF position; then SLOWLY advance the control to a position between OFF and maximum to establish the desired degree of FM about the center frequency. Because of the characteristics of the klystron, unstable operation will occur when the control has been advanced so that the f-m deviation is greater than the stable portion of the mode. Deviations of $\pm$ 3 megacycles or more can be obtained.

d. Connect r-f cable between RF OUTPUT connector (19) on signal generator and load.

e. If desired, connect video cable between SYNC OUT connector (22) and external equipment.

2-12. EXTERNAL PULSE MODULATION. (See figure 2-1.)

a. Set MOD SELECTOR switch (13) to the EXT+ or EXT- position, as required by the polarity of the external modulating pulse available.

b. Connect external modulation pulse to the EXT MOD connector (20) on the front panel. External pulse should have an amplitude of at least 15 volts peak.

c. No output pulses other than the r-f output are available under this condition.

2-13. EXTERNAL FREQUENCY MODULATION

a. Set the MOD SELECTOR switch (13) to EXT FM position.

b. Connect external modulation voltage to the EXT MOD connector (20) on the front panel. A source voltage of 20-30 volts rms is desirable.

c. Set FM AMPLITUDE control (12) to OFF position; then SLOWLY advance the control to a position between OFF and maximum to establish the desired degree of FM about the center frequency. Because of the characteristics of the klystron, unstable operation will occur when the control has been advanced so that the f-m deviation is greater than the stable portion of the mode. Deviations of $\pm$ 3 megacycles or more can be obtained.

d. No output other than r-f output is available under these conditions.

2-14. TURNING OFF EQUIPMENT

Regardless of the positions of the other controls place the ON switch in the OFF down position. This removes power from all electronic circuits and applies power to the space heaters. To completely remove power from the instrument, the power cable must be disconnected.

SECTION III

THEORY OF OPERATION

3-1. GENERAL

Signal Generator TS-621/U is designed to generate super-high frequency signals from 3800 to 7500 megacycles per second at amplitudes between 0 and -127 db below 1 milliwatt (0.228 volt to 0.1 microvolt). It is designed to work into an external load of 52 ohms. The power output control is calibrated directly in voltage and in decibels (db).

3-2. Front panel adjustments are provided to select the following types of r-f output.

a. Continuous wave (CW) output.

b. Internally developed square wave pulses at a pulse repetition frequency adjustable from 40 to 4,000 pulses per second.

c. Pulsed r-f output from internally-generated modulating pulses with a pulse width adjustable from 0.5 to 10.0 microseconds. These pulses may be synchronized either by the internal time base circuits which are adjustable between 40 and 4,000 pulses per second or by externally-developed sine wave or positive or negative synchronizing pulses with an amplitude from 5 to 50 volts.

d. Pulsed r-f output from an externally-applied negative or positive modulation pulse having a peak amplitude of 15 to 70 volts, a pulse width of 0.5 to 2500 microseconds and a pulse separation of 1.0 to 2500 microseconds.

e. Internally developed sawtooth frequency-modulated r-f output at a recurrence rate adjustable from 40 to 4,000 cycles per second and a frequency deviation adjustable from 0 to ± 3 megacycles per second.

f. Frequency-modulated r-f output from externally-applied sine wave or sawtooth voltages with a recurrence rate between 40 and 4,000 cycles per second.

3-3. The signal generator also provides two external synchronizing pulses for use in synchronizing external equipment when the internal synchronizing and modulating circuits of the

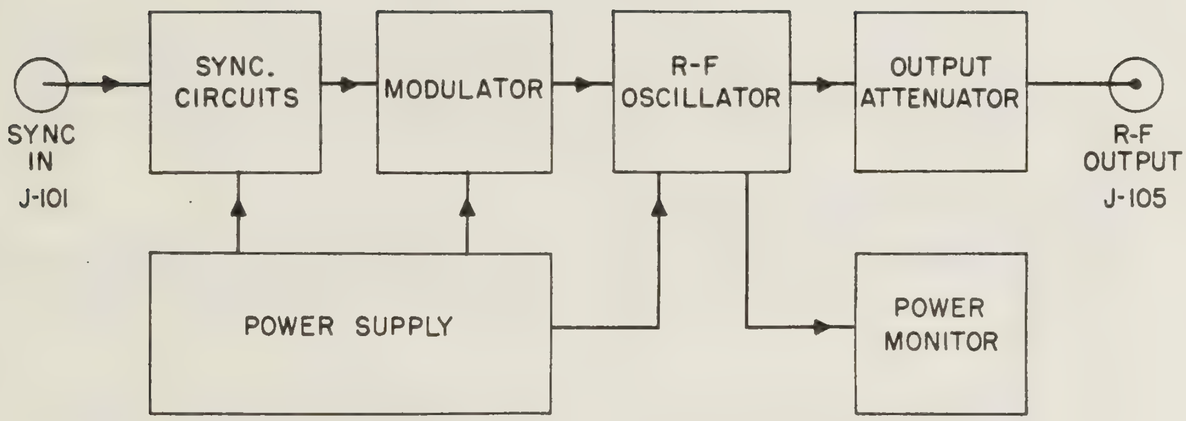


FIG. 3-1 SIGNAL GENERATOR TS-621/U CIRCUIT BLOCK DIAGRAM

unit are employed. These are:

a. SYNC OUT synchronizing pulse, a positive voltage pulse with a very steep wave-front occurring at essentially the same time as the synchronizing signal. It has an amplitude of greater than 25 volts when connected to a load having a resistance of 1000 to 100,000 ohms and a shunt capacitance of 500 micro-microfarads or less. The pulse width is approximately two microseconds.

b. DELAYED SYNC OUT synchronizing pulse, a positive voltage pulse occurring essentially with the start of the output r-f pulse. Its characteristics are the same as the SYNC OUT signal described above.

3-4. <u>GENERAL SYSTEM OPERATION</u>

Signal Generator TS-621/U contains the six basic circuit elements shown in the System Block Diagram, figure 3-1. These are:

a. Synchronizing Circuits to establish the repetition rate of the modulation pulse applied to the r-f oscillator.

b. Modulator Circuits to develop a positive pulse to be applied to the klystron modulator grid.

c. An r-f Oscillator Circuit which receives the positive modulation pulse and generates the r-f output pulse.

d. Output Attenuator, a coupling system that adjusts the r-f output to the desired power level.

e. Power Monitoring System to monitor the power level existing in the r-f oscillator and to provide a reference from which to calibrate the output power level.

f. Power Supply Circuits which develop the operating voltages employed by the electronic components of the generator.

3-5. Various types of modulation are possible by operation of the panel switches. Provisions are incorporated in the generator to disconnect the internal pulse-generating circuits and to employ externally developed modulation voltages when desired.

The detailed operation of the basic circuits is described in the following paragraphs.

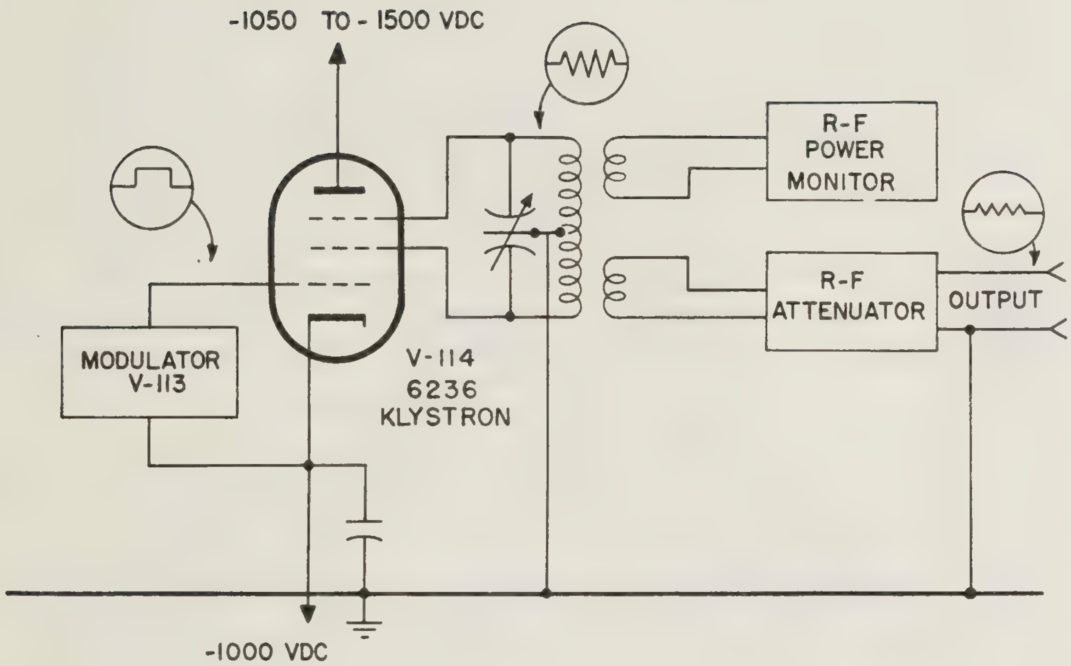


FIG. 3-2 EQUIVALENT CIRCUIT OF R-F OSCILLATOR

3-6. R-F OSCILLATOR SYSTEM.

The r-f oscillator develops the r-f output voltage that is applied to the load. The oscillator employs a type 6236 reflex klystron and a tunable parallel-plane line section as a resonant tank circuit. The conventional equivalent electrical circuit is shown in figure 3-2. The resonant line circuit is connected between the two resonator grids of the klystron tube. The grid located between the resonator grids and the cathode is the modulator grid. It controls the flow of electrons from the cathode when a positive modulation pulse is present. The resonator and modulator grids are of open construction so as to present little physical opposition to the passage of electrons through them when electrical conditions are favorable. The electrode at the end of the tube is the repeller, and a voltage is placed upon it that is negative with respect to the resonator grids. This repels the electrons back towards the resonator grids.

When the circuit is in oscillation, the potentials at the two resonator grids are continuously changing at a rate equivalent to the frequency of oscillation. This causes some electrons to be accelerated, while others are decelerated during their passage through the grids. The result is that the electron stream is broken up (the electrons "bunched") into sections of heavy and light density in the area between the grids and the repeller.

The distance that the bunched electron stream will travel beyond the resonator grids and their rate of travel after they have been repelled by the negative repeller electrode is determined by their initial speed and by the value of negative voltage on the repeller.

Oscillation is sustained when these factors are adjusted so that the bunches of negative electrons arrive back at the resonator grids when the oscillating voltage at these grids is such that it opposes the passage of electrons. The electrons therefore give up their energy to the grids so as to reinforce the oscillating current of the tank circuit, thus replacing power losses due to circuit resistance and power delivered to the load. This is a form of regeneration, and serves to maintain oscillation in the circuit.

3-7. POWER MONITOR AND ATTENUATOR.

Two pickup loops are located in the resonator to collect r-f power. The first is the output attenuator loop which

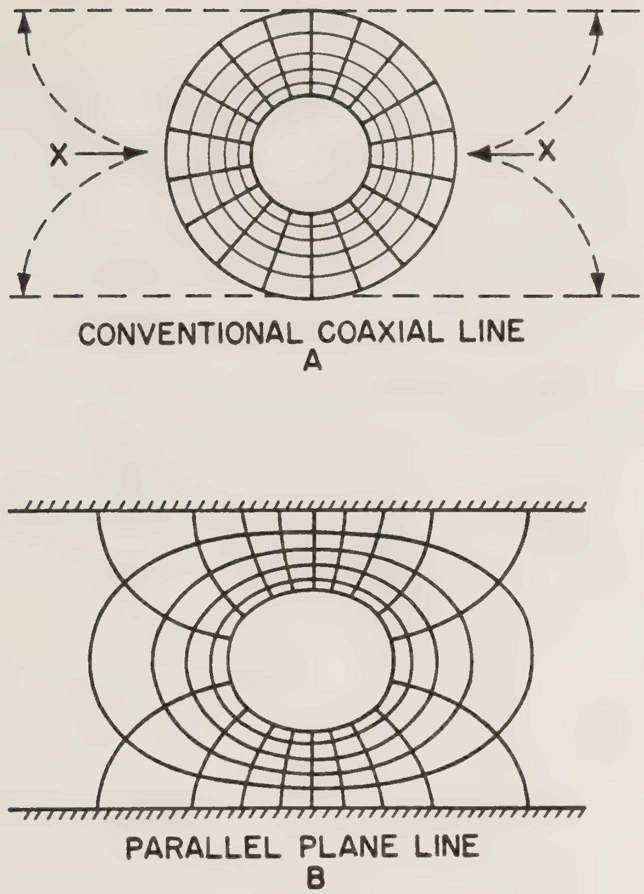


FIG. 3-3 FIELD CONFIGURATIONS OF COAXIAL AND PARALLEL-PLANE LINES

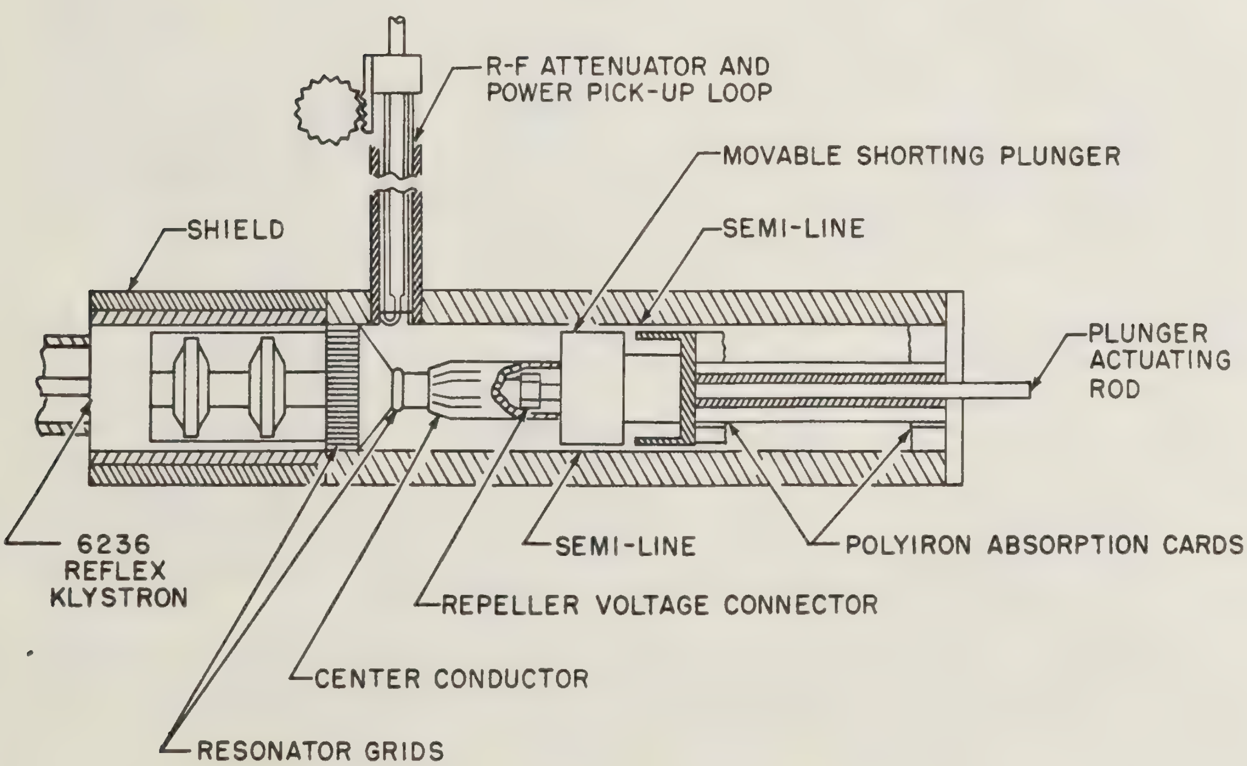


FIG. 3-4 CUTAWAY VIEW OF R-F OSCILLATOR

couples the power to be supplied by the generator to the load through an output connector on the panel. The position of this loop is adjustable so that the output power level may be varied as desired. The second is the power monitoring loop which monitors the power level in the oscillating circuit and establishes a reference point to calibrate the output power.

3-8. PARALLEL PLANE RESONATOR.

The tank circuit employed in RF Signal Generator TS-621/U is known as a parallel plane resonant line. In its physical shape it resembles a rectangular box type cavity with a circular center element and a rectangular plunger to vary the cavity depth.

Actually the line is a direct development from a circular coaxial line as shown in figure 3-3. Part A of figure 3-3 shows such a line, and the field configurations that exist when it is excited electrically. The resonant frequency of such a line with one end shorted is determined by its electrical length in a direction parallel to the center conductor. The other dimensions of the line play a very small part in determining the oscillating frequency.

The evolution of the parallel plane line from the coaxial line may be described by reference to figure 3-3, parts A and B. Assume the outer conductor were cut at the points "X" and the two semi-lines thus created were flattened out as shown by the horizontal dotted lines. The voltage and current configurations would then take the form shown in part B. To carry this example through in complete detail, the cross-section of the center conductor would take a slightly elliptical form of perfect configurations. However, for practical purposes, this is not necessary, and a circular center conductor is used.

The line, as shown in figure 3-3, part B is not enclosed on the short sides, and it is possible to operate it in this manner. However, in Signal Generator TS-621/U, sides are provided to prevent stray r-f leakage currents.

The parallel plane line depends, for its resonant frequency, upon its electrical length and consequently may be tuned by simple mechanical means and can be directly calibrated.

This type of cavity provides a resonator in which simple and straightforward methods can be employed to provide

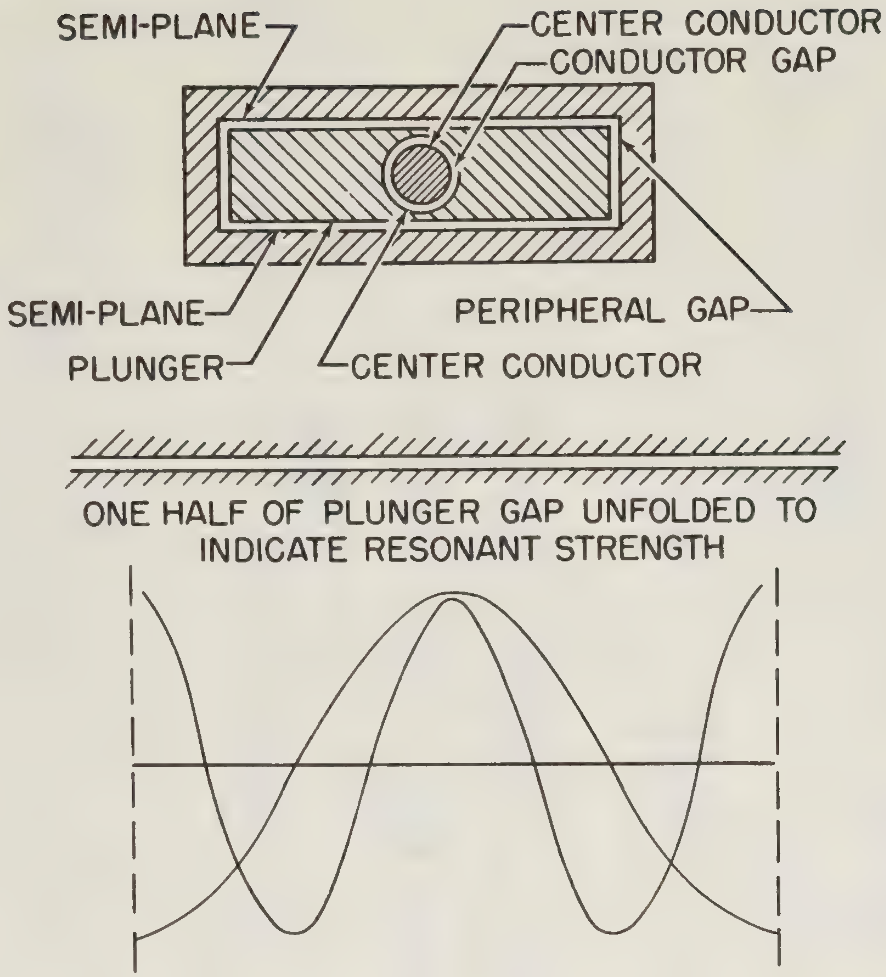


FIG. 3-5 PLUNGER RESONANCES IN UNCOMPENSATED PARALLEL-PLANE LINE RESONATOR

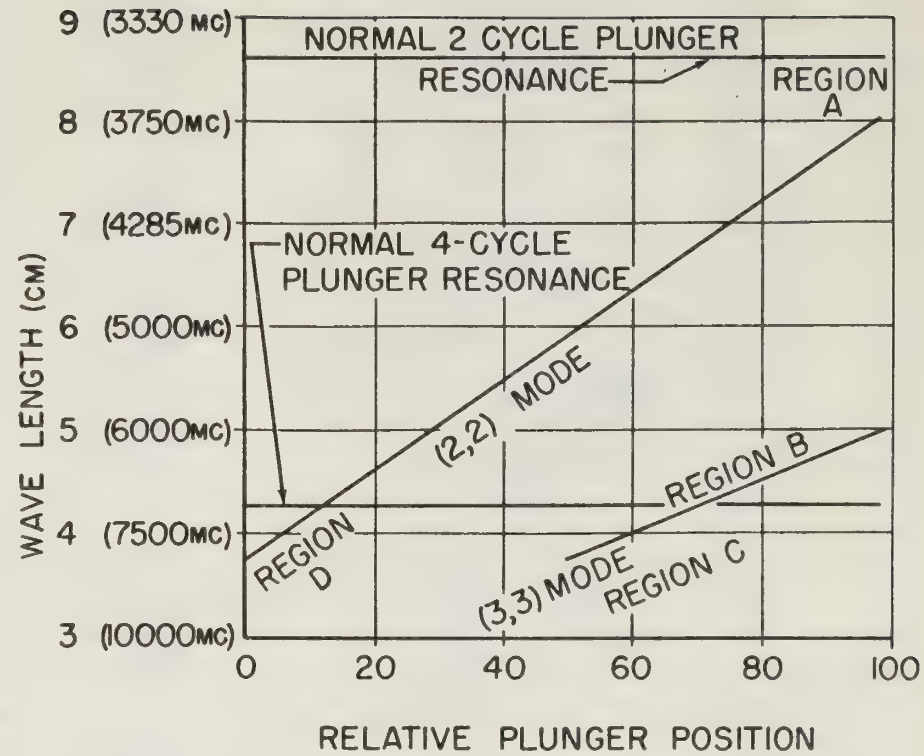


FIG. 3-6 FREQUENCY PLOT OF UNCOMPENSATED RESONATOR

broad band suppression of the various parasitic resonances that occur when other physical dimensions approach the frequency-determining electrical dimensions.

Figure 3-4 shows a cut-away view of the resonant line and the other components of the parallel plane oscillator as employed in Signal Generator TS-621/U. The type 6236 reflex klystron is mounted so that one of the resonator grids is coupled to the two semi-lines while the other is coupled to the circular center conductor. The repeller voltage is applied through an insulated filter in the center conductor while the other potentials required to operate the tube are applied through the tube base pins.

3-9. PLUNGER RESONANCE.

The plunger employed in the parallel plane resonator is of the non-contacting type and a small air gap exists between the periphery of the plunger and the surfaces of the semi-planes and sidewalls, as shown in figure 3-5.

This gap has a physical length of approximately 17 centimeters, and an electrical length such that it has a two-cycle and a four-cycle resonant frequency occurring near or in the frequency range of the oscillator. As shown in figure 3-5, these frequencies correspond to one-half and one quarter of the electrical length of the periphery of the plunger.

A similar gap exists between the center conductor and the plunger. However, the length of this gap is such that no resonances occur in the frequency range of the oscillator.

Compensation is applied to control resonance of the line formed by the peripheral plunger gap in the resonator employed in Signal Generator TS-621/U.

3-10. FREQUENCY PLOT OF UNCOMPENSATED RESONATOR.

Figure 3-6 shows a frequency plot of an uncompensated parallel plane resonator covering the range between 3,800 and 7,500 megacycles per second. It indicates that four resonances may exist throughout portions of the frequency band.

The two peripheral plunger resonances will be found at approximately 3,500 and 7,000 megacycles per second. Since these resonances are due to the distance around the periphery of the plunger, they are unaffected by the position of the plunger in the resonator.

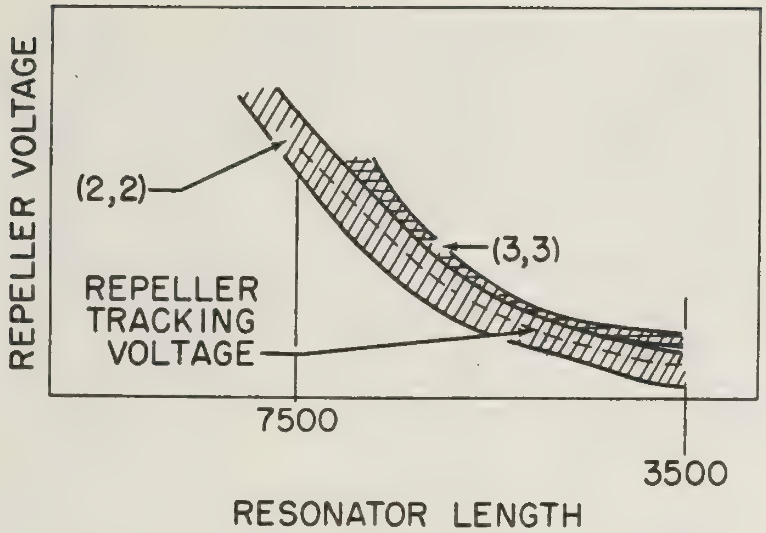


FIG. 3-7 PARTIAL PLOT OF KLYSTRON MODES

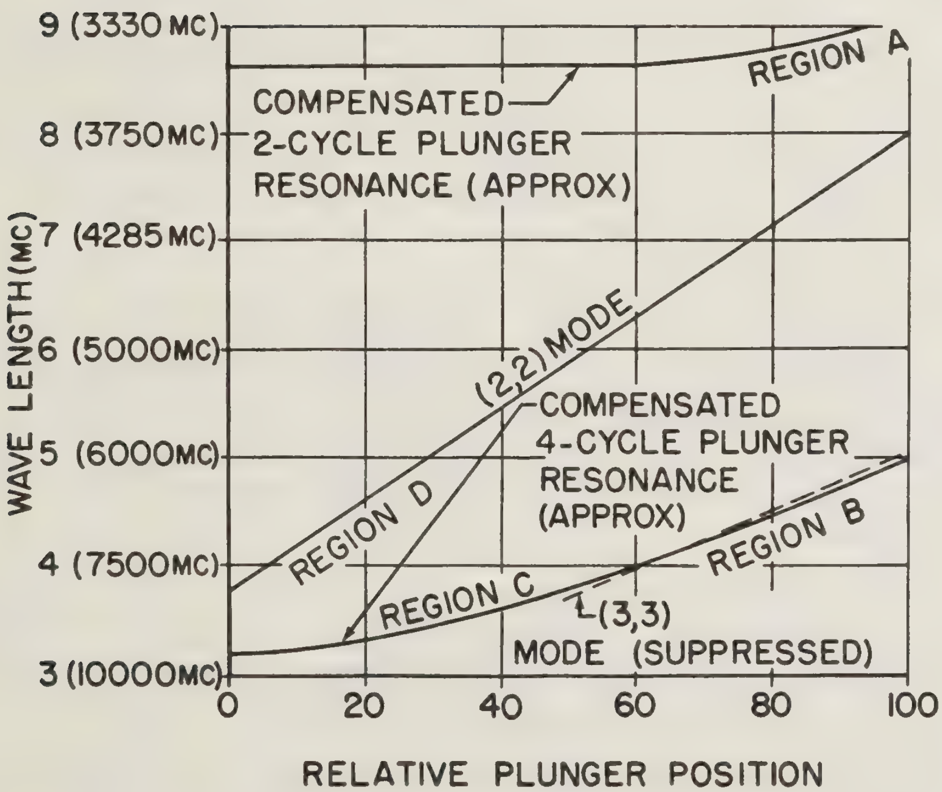


FIG. 3-8 FREQUENCY PLOT OF COMPENSATED RESONATOR

The presence of these resonances is highly undesirable, since they tend to absorb power, usually damping out the desired oscillation and causing a dead or reduced power spot in the tuning range when the resonator is tuned to their approximate frequencies.

The desired frequencies of operation, plotted in relation to the percentage of total plunger travel is indicated by the upper heavy slanting line in figure 3-6. The type 6236 tube operates in the 2-3/4 (2,2) mode and this mode is continued throughout the entire frequency range of the signal generator.

An interesting resonance is shown by the lower sloping line. It consists of higher-order modes that tend to track with the desired mode throughout the tuning range. A condition is established where the (3,3) mode very closely follows the (2,2) mode. The partial mode plot of the oscillator shown in figure 3-7 shows the close proximity of the undesired and desired modes throughout their entire frequency range.

The result of employing the resonator without compensation would be that two oscillating frequencies could be obtained over the low frequency half of the desired frequency range. This would cause a highly unstable oscillating condition to exist, with the circuit oscillating at one of the possible frequencies, then shifting to the other and back again, between modes. This condition would be especially pronouced during pulse modulation.

The two horizontal lines show the two-cycle and four-cycle resonances of the peripheral plunger gap. At the low-frequency end of the range, the desired resonance approaches the two-cycle plunger resonance, while the desired resonance actually coincides with and crosses the four-cycle plunger resonance at approximately 7000 megacycles per second.

When the desired resonance approaches the plunger resonance, it loads the oscillating circuit, often to the point where the desired resonance is completely damped out, causing reduced power or dead spots to appear in the tuning range.

The method of compensation employed to eliminate undesired resonances is described in the following paragraphs.

3-11. RESONATOR AND PLUNGER COMPENSATION.

In order to compensate for the various undesired resonances shown in figure 3-6 and 3-7, the length of the resonant line

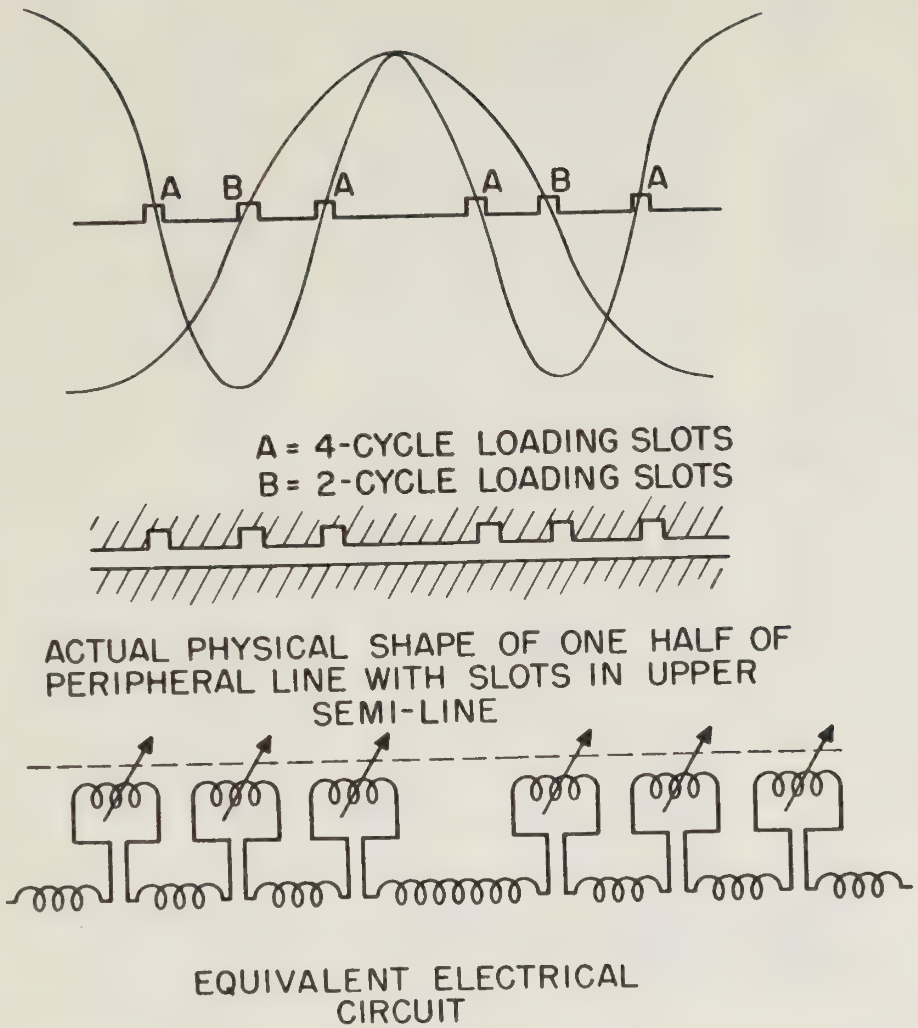


FIG. 3-9 COMPENSATION OF PLUNGER RESONANCE AT LOWER FREQUENCIES

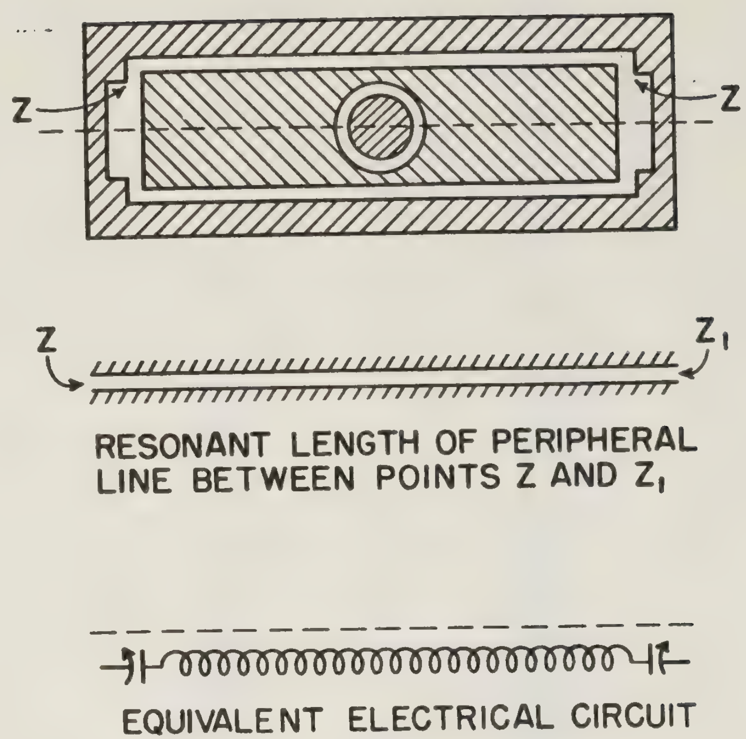


FIG. 3-10 COMPENSATION OF PLUNGER RESONANCE AT HIGHER FREQUENCIES

around the periphery of the plunger is caused to vary in length electrically as the plunger is moved physically between the semi-planes. Figure 3-8 shows a compensated frequency plot of the resonator obtained this way.

In region B at the low-frequency end of the tuning range the electrical length of the peripheral line is increased in such a manner that the four cycle resonant frequency of the plunger coincides with the frequency of the (3,3) mode throughout this range. This essentially damps out oscillation in this mode by loading the oscillating circuit.

Figure 3-8 also shows the lowering in frequency of the two-cycle plunger resonance so that, in region A, a much greater frequency difference exists, and no damping action can take place.

The manner in which this is accomplished is shown in figure 3-9. Slots are placed in the resonator walls. These slots inductively load the peripheral resonant line increasing its electrical length and lowering its resonant frequency to coincide with the (3,3) mode. The depth of these slots is tapered so as to cause the peripheral resonance to coincide with the undesired resonance as the plunger is moved. An equivalent electrical circuit, using conventionalized inductance symbols is shown on figure 3-9.

In region C, the four-cycle plunger resonance is lower than the undesired (3,3) mode. It is necessary to shorten the electrical length of the peripheral line to track with this mode. Figure 3-10 shows the manner in which this is accomplished.

Slots are placed in the side walls of the resonator. These slots present a capacitive reactance, acting as high impedance sections and presenting a high impedance to the line at the points Z and Z_1. This reduces the electrical length of the line and raises its resonant frequency. By varying the width and depth of those slots, the peripheral resonance is made to track with the frequency of the (3,3) mode in region C, effectively dampening the undesired oscillation in this mode.

The effect of these slots in the side walls is continued in region D, and utilized to further raise the frequency of the peripheral line so that its frequency remains considerably higher than the desired frequency in the (2,2)

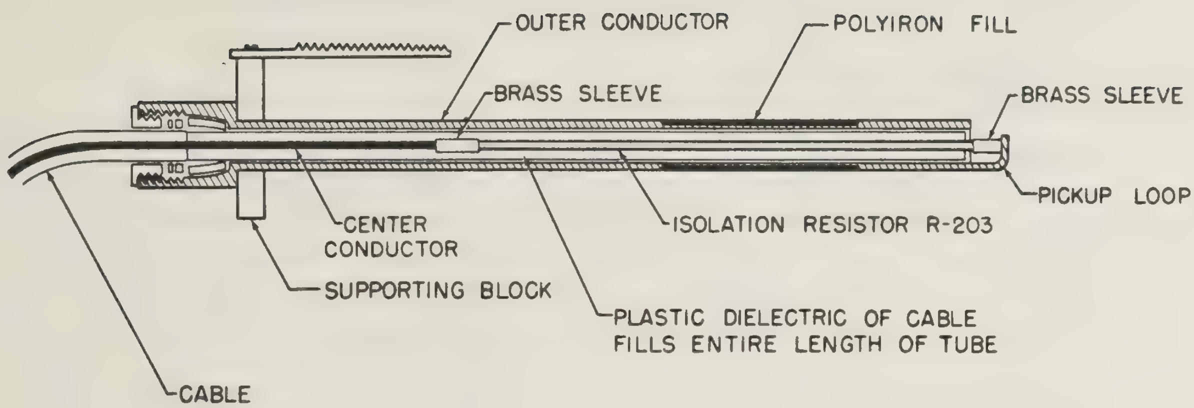


FIG. 3-11 CUTAWAY VIEW OF ATTENUATOR PROBE

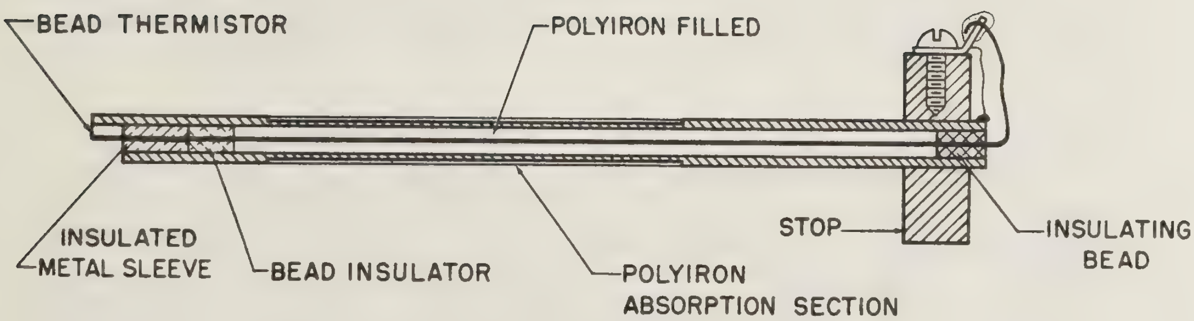


FIG. 3-12 CUTAWAY VIEW OF POWER MONITOR PROBE

mode, thus avoiding the dampening effects that would take place with an uncompensated line.

3-12. COUPLING METHODS

Power is coupled to the load from the r-f oscillator by a coupling loop located at a suitable point in the resonant line. This loop slides in a circular waveguide section (figure 3-4). The cross section of the waveguide is very small in relation to the frequencies of operation, and normal propagation down the waveguide will not take place.

However, some limited propagation does take place, and the power level decreases exponentially as the distance from the resonant line increases. Thus it is possible, by moving a pickup loop linearly in the waveguide to secure an output that varies in decibels in proportion to the linear travel.

This type of attenuator is known as an attenuator of the cut-off type and its characteristics are employed so that the pick-up probe and indicating dial can be moved by a simple gear train and the dial may be calibrated directly in decibels.

A cross-section of the attenuator and r-f pick-up loop is shown in figure 3-11. The pick-up loop couples r-f energy from the wave guide section. The assembly consists of an external metal conductor covering section of RG-55/U cable, replacing the outer shield. A three-inch section of the center conductor has been removed and is replaced by resistor R-203.

This resistor is made by plating platinum on a 1/32-inch diameter glass rod, and its value is such that it introduces a 10 db loss in the line. Its dc resistance is approximately 100 ohms. The purpose of resistor R-203 is to terminate the r-f cable so that it appears to be essentially 52 ohms at the end near the generator. This causes the internal impedance of the r-f generator also to appear as 52 ohms. It does this by reducing any power sent down the line towards the generator by dissipating it in the resistor. The reflected waves are reduced by this loss, thus reducing the standing waves on the line.

The polyiron section on the outside of the probe is designed to absorb power that may leak past the probe in the space between the outer conductor and the wave guide walls.

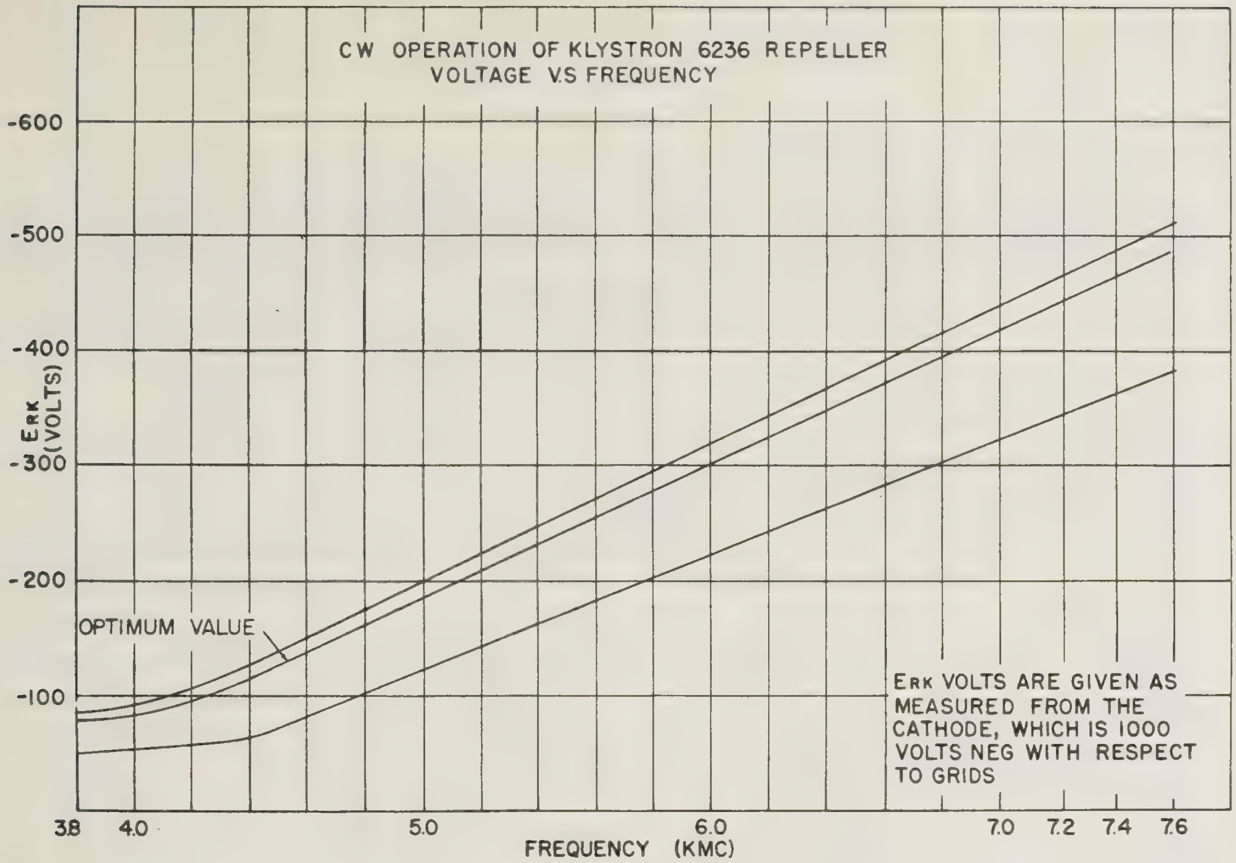


FIG. 3-13 PLOT OF REPELLER VOLTAGE VS FREQUENCY

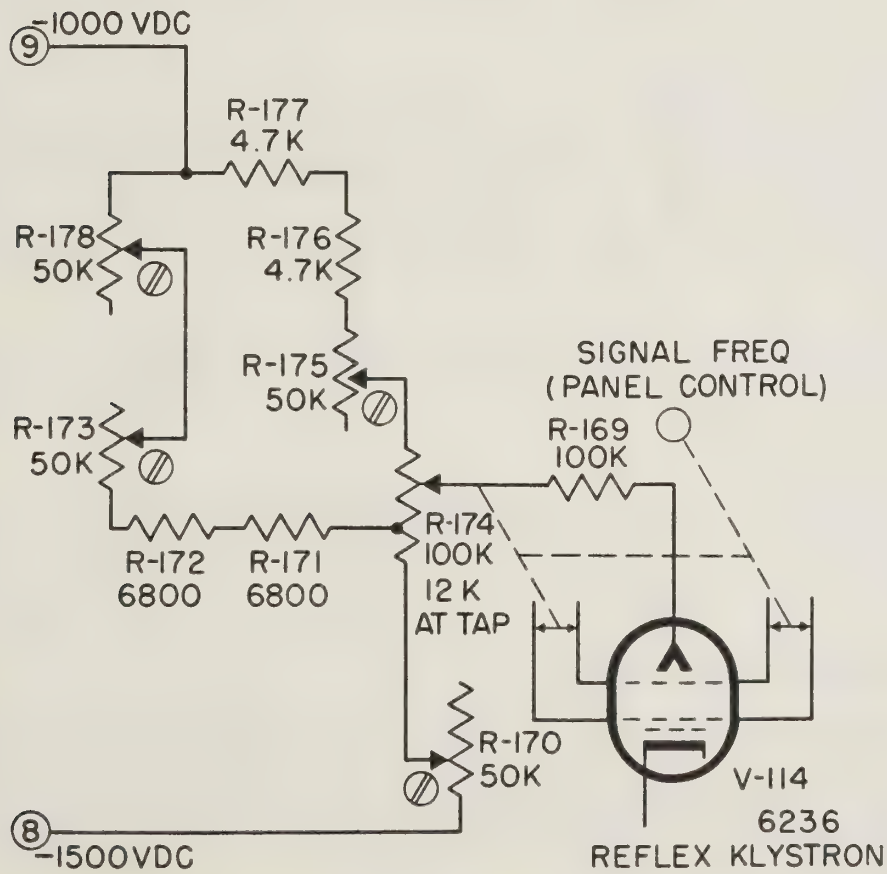


FIG. 3-14 SCHEMATIC OF KLYSTRON REPELLER
VOLTAGE TRACKING CIRCUITS

The power monitor r-f probe, shown in figure 3-12, is constructed similarly to the attenuator probe, except that a bead thermistor R-202 is located at the end of the probe, and no resistor is placed in the line. This bead thermistor acts as a power-metering bolometer when employed in the bridge circuit described in paragraph 3-14.

3-13. REPELLER VOLTAGE CONTROL

The operating characteristics of a reflex klystron are such that an optimum value of repeller voltage exists for each operating frequency. This voltage is the value that will cause the bunched electrons to return to the resonator grids at the proper time. Figure 3-13 shows the repeller voltage characteristics for the type 6236 klystron over the range employed in the signal generator.

The repeller voltage characteristic shown in figure 3-13 provides for operation in the 2-3/4 repeller mode. The required voltage for optimum operation is essentially linear with frequency for the frequency range above 4400 mc. In the frequency range from 3800 to 4400 mc the required voltage is not a linear function of frequency but is slightly curved as shown.

Figure 3-14 shows the circuit that provides negative voltage to the repeller. R-174 is a 100,000 ohm wire-wound potentiometer that is mechanically ganged with the mechanism that tunes the resonant line, providing a proper voltage to the repeller electrode as the frequency is changed.

The values of the resistors R-170 and R-175 are adjustable to establish the voltage applied across the tracking potentiometer R-174.

The values of resistors R-173 and R-178 are adjustable to provide the required curvature in the repeller voltage characteristic below 4400 mc.

3-14. POWER MONITOR CIRCUIT

The power generated by the oscillator varies with frequency, primarily because of the characteristic of klystrons. Therefore, a power monitor circuit is included to indicate the level of the field at the attenuator input.

The power in the resonator is monitored by the thermistor bridge circuit shown in figure 3-15. The bead thermistor

R-202, which is one arm of the bridge, is located in the piston type probe described in last paragraph of 3-12. This probe couples a small amount of power from the resonator and the resistance of the bead thermistor varies due to the heat developed as this power is dissipated in the thermistor itself.

The bridge circuit employed is sometimes called a "two-disc" bridge circuit, because two disc-type thermistors are used to compensate for sensitivity and temperature. It is essentially a Wheatstone bridge circuit, and the bead thermistor R-202 forms one arm.

The bridge is balanced for d-c conditions. When r-f power from the resonator is applied to the thermistor, the bridge becomes unbalanced. The balance indicating device is M-101, a 200 microampere meter, connected across the bridge to indicate circuit balance. R-201 is a disc-type thermistor connected in parallel with the meter and it acts as a sensitivity regulator to counteract the tendency of the bridge to decrease in sensitivity as the temperature applied to the bridge increases.

A second disc thermistor, R-200 is shunted across the bridge in series with limiting resistor R-183. This acts as a balance regulating device to compensate for unbalance due to resistance changes in R-202 caused by variations in ambient temperature. An ambient temperature increase will cause the resistance of R-202 to decrease causing more current to flow through its leg of the bridge, increasing the meter reading by unbalancing the bridge. R-200 will also decrease in resistance, causing a drop in the total voltage across the bridge and a decrease in current flow through its various legs, thereby decreasing the meter reading.

Since the static resistance of R-202 is determined by both the ambient temperature and the static bridge current flowing through it, the decrease in bridge current caused by the actions of R-200 will act to decrease the temperature of R-202 and tend to restore the static balance of the bridge. The two disc thermistors are mounted directly on the resonator so that they are immediately sensitive to temperature changes.

R-f power in the coupling loop is isolated from the bridge since sufficient stray capacity exists in the

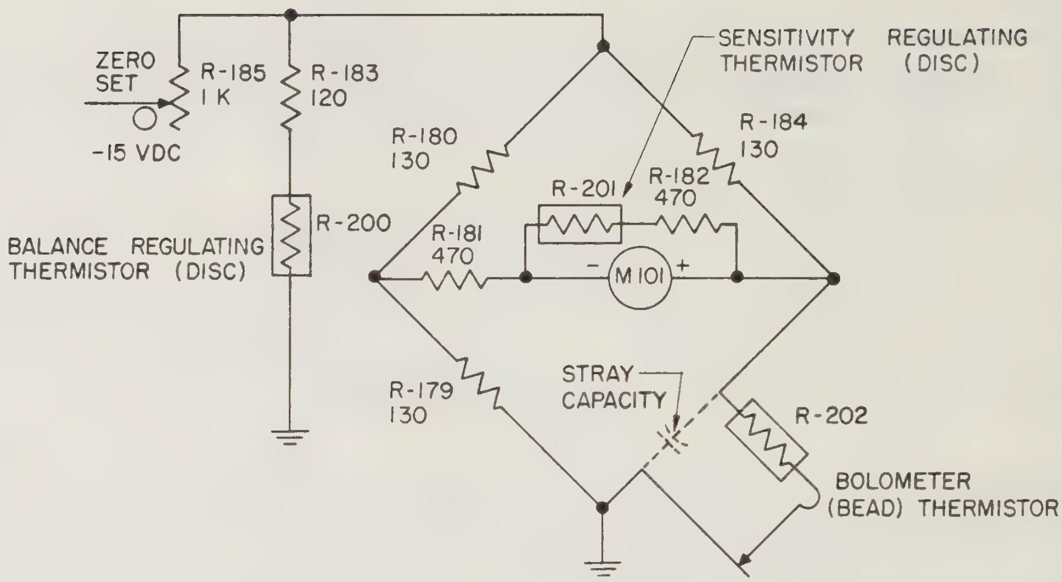


FIG. 3-15 SCHEMATIC OF POWER LEVEL MONITOR CIRCUIT

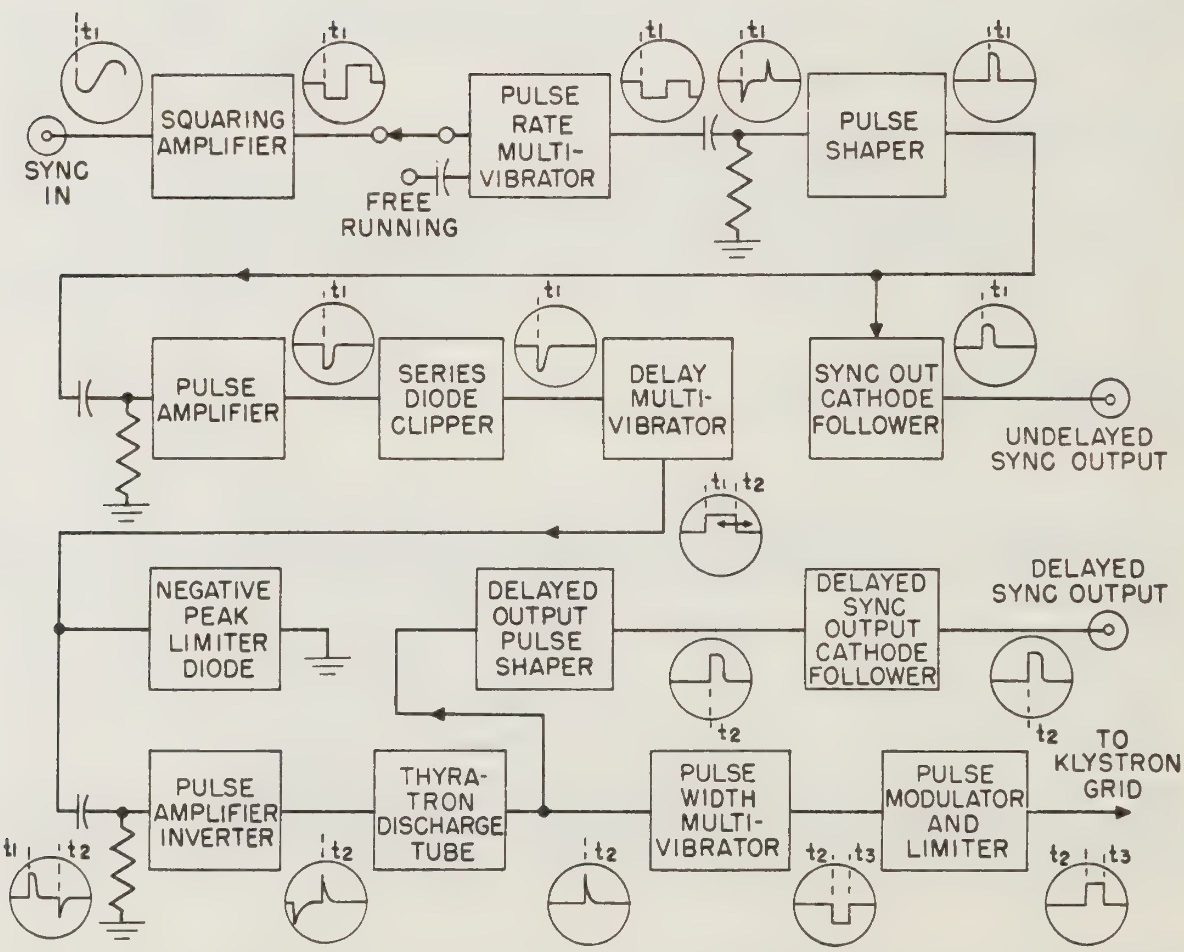


FIG. 3-16 BLOCK DIAGRAM OF MODULATOR CIRCUIT

probe and line to effectively bypass it to ground. This is indicated by the dotted capacity shown in figure 3-15.

3-15. EMPLOYMENT OF POWER MONITORING CIRCUITS.

The power monitor probe is moved within its wave guide in a manner similar to the power attenuator pickup probe. Its position is controlled by the POWER SET control on the front panel and is indicated by the position of the transparent index scale over the calibrated OUTPUT ATTEN (attenuator) dial.

The power level existing at the location of the probes in the resonator varies as the signal generator is tuned over its frequency range. To compensate for this, the position of the power monitor probe is moved so that it picks up the amount of power necessary to balance the bridge. This establishes the basic reference level for 1 milliwatt and positions the transparent index scale over the attenuator dial. The attenuator control is then adjusted with reference to this index scale to provide the desired attenuation below 1 milliwatt as read on the calibrated dial.

The OUTPUT ATTENUATOR control moves the output attenuator probe mechanically and also moves the calibrated dial. Thus when any calibration point on the dial is under the index line, the position of the output probe in its wave guide is proportional to that of the power indicating probe (which has been set to the proper reference level) and the power output may be read directly on the dial.

Movement of the output probe in its wave guide will cause attenuation as described in paragraph 3-12. The power indicating dial is calibrated in decibels below one milliwatt when coupled to a 52-ohm load.

3-16. MODULATOR SECTION

The modulator section is shown in block diagram form in figure 3-16. The function of the circuits in this section are to establish a modulating pulse (for pulse operation) or a sawtooth voltage (for frequency modulation) and to apply it to the r-f oscillator so as to secure the desired type of r-f output.

Various portions of these circuits are not employed in certain types of operation such as when external pulse

or frequency modulation voltages are provided. However, the block diagram shows the condition where all of the circuits are employed (delayed pulse output with external synchronization) and the description will cover this type of operation. Other types of operation will be described in later paragraphs.

The Squaring Amplifier V-101A and V-101B is designed to accept either sine waves, or positive or negative synchronizing pulses. It converts sine waves into a steep negative wave front necessary to trigger the Pulse Rate Multivibrator. With positive pulses it acts as an amplifier and inverter. With negative pulses it acts as a straight amplifier. The input desired is selected by a switch on the control panel.

The Pulse Rate Multivibrator V-103A and V-103B acts as a one-shot multivibrator when external sine wave synchronization is employed. When internal timing is desired, the circuit constants are switched and it acts as a free-running time base multivibrator with a repetition rate adjustable from 40 to 4,000 cycles per second. Its output is essentially square wave in character.

The output of the Pulse Rate Multivibrator is differentiated and applied to the Pulse Shaper V-104A and V-104B. This circuit is a one-shot multivibrator with a two-microsecond time constant that operates on the differentiated negative pulse and produces a positive pulse of two-microseconds duration.

This voltage is applied to the Pulse Amplifier V-105A to produce a negative output pulse of two-microseconds duration. The voltage from the pulse shaper is also applied to the Sync Output Cathode Follower V-105B and provides the undelayed sync-output voltage available for synchronizing external equipment.

The output of the Pulse Amplifier is applied to the Delay Multivibrator V-107A and V-107B through a series diode base limiter V-106A that removes any positive voltage transients and permits only the negative pulses of sufficient amplitude to be applied to the multivibrator. The delay multivibrator output is a positive pulse with the leading edge essentially coincident in time with the synchronizing voltage. The trailing edge appears at a later time (t_2) that is determined by the adjustment of the PULSE DELAY front panel control. From 3 to 300 microseconds delay may be provided between t_1 and t_2.

The Negative Base Limiter Diode V-106B acts to bypass negative transients following the trailing edge of the output of the Delay Multivibrator. The output of the Delay Multivibrator is differentiated into a positive voltage spike at t_1 and a negative spike at t_2.

This differentiated output is applied to the Pulse Amplifier Inverter V-109A that inverts it so that the negative spike appears at t_1 and the positive spike at t_2.

The Thyratron Discharge Tube V-110 is biased for non-conduction. The positive spike, however, causes the tube to ionize and conduct current at t_2.

A positive voltage spike is taken from the cathode and applied to the Delayed Output Pulse Shaper V-115A and V-115B and the Pulse Width Multivibrator V-111A and V-111B at t_2.

The Delayed Output Pulse Shaper V-115A and V-115B shapes the pulse into a positive pulse, essentially 2 microseconds in duration. This is supplied to Delayed Sync Output Cathode Follower V-109B. This stage acts as an impedance transforming device and its output is a positive two-microsecond pulse at t_2 that is available at the DELAYED SYNC OUT connector J-104 for synchronizing external equipment.

The output of the Thyratron Discharge Tube when applied to the Pulse Width Multivibrator causes this circuit to develop a negative pulse with the leading edge appearing at t_2 and the trailing edge at t_3. The duration of the pulse is adjustable from 0.5 to 10 microseconds by the calibrated PULSE WIDTH panel control.

The negative pulse from the Pulse Width Multivibrator is applied to the Pulse Modulator V-113. This stage amplifies and inverts the pulse and applies it to the klystron grid, activating the tube during the period the pulse is present. Two diodes are employed in the modulator circuit. One is a positive peak clipper on the input circuit while the other acts as a bias regulator for the r-f oscillator circuits. The positive peak clipper protects the modulator tube by preventing any voltages more positive than a pre-determined value from reaching its grid. The diode bias regulator clamps

the bias voltage on the klystron modulation grid to a value that establishes proper beam current for the klystron under any condition of modulation.

3-17. INTERNAL F-M OPERATION.

Internal sawtooth voltage for application to the repeller electrode is developed by transforming the thyratron discharge circuit into a relaxation oscillator. When triggered by the Pulse Rate Multivibrator, it generates a sawtooth wave as its output. The amplitude of this sawtooth wave is not controllable. However, the FM AMPLITUDE control on the front panel controls the amplitude of the sawtooth voltage applied to the r-f oscillator.

3-18. CONTINUOUS-WAVE OPERATION.

C-W operation is obtained by placing a fixed positive voltage on the r-f oscillator modulation grid to permit continuous operation.

3-19. EXTERNAL PULSE MODULATION.

External positive pulses are applied through the Pulse Amplifier Inverter (figure 3-17) to the Pulse Modulator while external negative pulses are applied directly to the Pulse Modulator.

3-20. EXTERNAL FREQUENCY MODULATION.

External frequency modulation voltages are applied directly to the repeller electrode of the klystron oscillator tube through the F-M AMPLITUDE panel control and an isolation capacitor. Either sawtooth or sine wave voltage may be applied. Voltages required for external frequency modulation at frequencies from 20 cps to 20,000 cps must be connected to the EXT. MOD input connector on the front panel.

CIRCUIT DESCRIPTION

3-21. SYNC INPUT CIRCUITS.

These circuits accept the external synchronizing voltage applied at J-101, the SYNC IN connector, and transform it into a negative pulse employed to trigger the pulse rate multivibrator V-103. The circuit elements

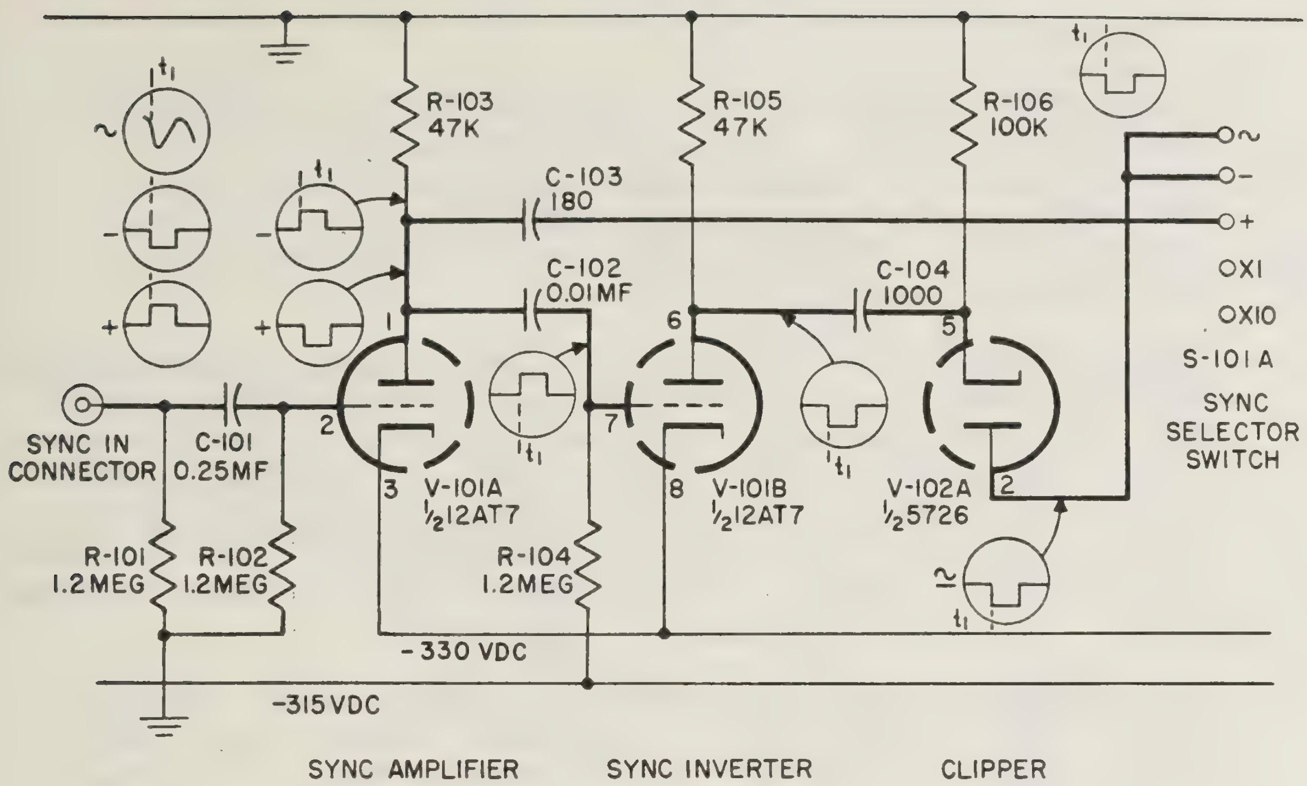


FIG. 3-17 BASIC SYNC INPUT CIRCUITS

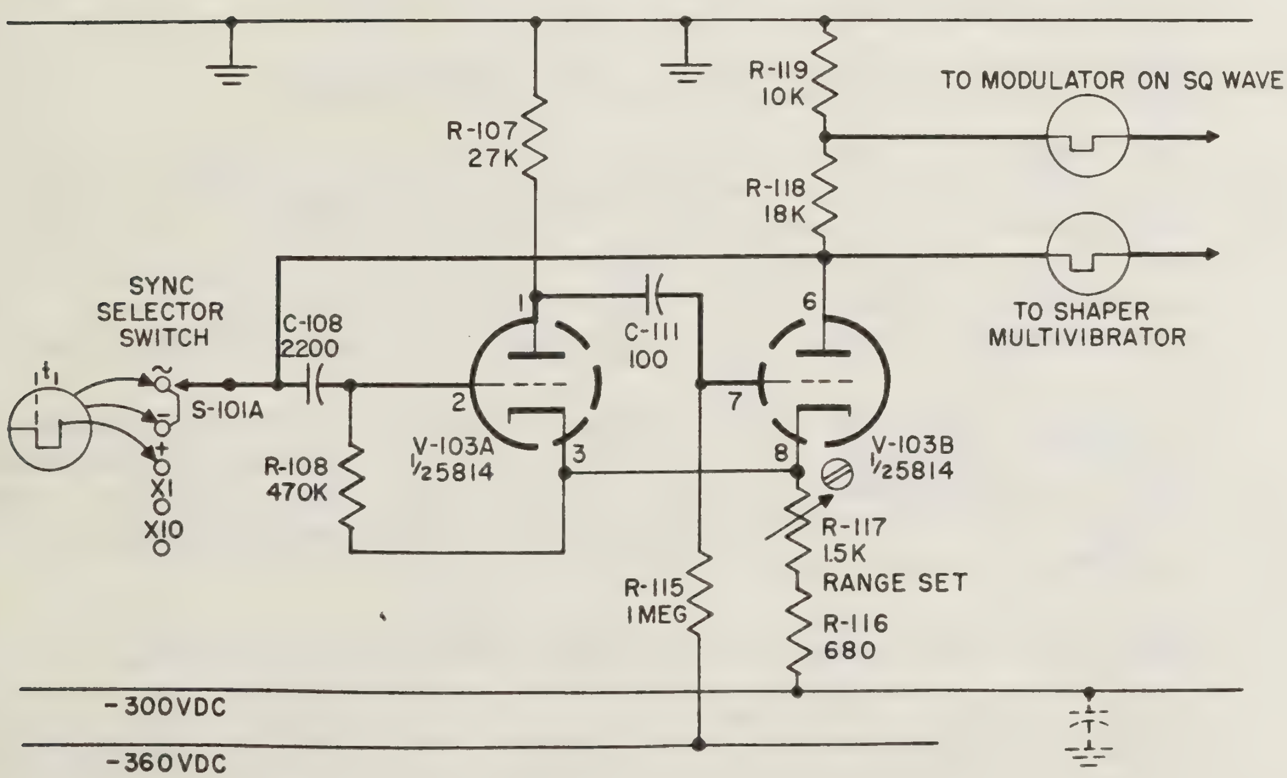


FIG. 3-18 BASIC PULSE RATE MULTIVIBRATOR, EXTERNAL SINE WAVE SYNC CONDITION

are shown in figure 3-17. V-101A is 1/2 of a type 12AT7 dual triode. The grid is returned to 3+ (ground). This places the grid at zero bias and the tube is drawing current through plate load resistor R-103. The tube responds to both positive and negative signals.

The negative-going portion of a sine wave synchronizing voltage, or a negative sync pulse, causes the tube to cut off, developing a positive pulse in its plate circuit. This is applied to the grid of V-101B. V-101B is cut off with a bias of -15 volts, and the positive voltage causes it to draw current through load resistor R-105, developing a negative pulse with a steep leading edge.

This negative pulse is applied to the ~ and - contacts of the SYNC SELECTOR switch S-101A through the series diode clipper V-102A. V-102A acts to apply only negative pulses to following circuits.

When a positive external sync pulse is applied to the grid of V-101A, a negative pulse is developed in its plate circuit and applied to the + contact of S-101A by capacitor C-103.

3-22. PULSE RATE MULTIVIBRATOR (SYNC CONDITION)

When external sine wave sync signals are employed, the sync multivibrator is switched to the operating condition shown in figure 3-18. This circuit is a standard one-shot multivibrator with V-103A drawing current as its grid is returned to its cathode while V-103B is cut off, its grid being returned to the -360 vdc line.

The negative pulse from the sync input circuits causes the multivibrator to switch at t_1, developing a negative pulse in the plate circuit of V-103B. The width of the pulse is determined by the length of time necessary to discharge capacitors C-111 through R-115.

3-23. PULSE RATE MULTIVIBRATOR (FREE-RUNNING CONDITION)

In the INT FM, INT (pulse), and SQ WAVE positions of the modulation selector switch S-102, the pulse rate multivibrator is converted to a free-running multivibrator (figure 3-19). Under this condition the sync input circuits are disconnected from the rate multivibrator.

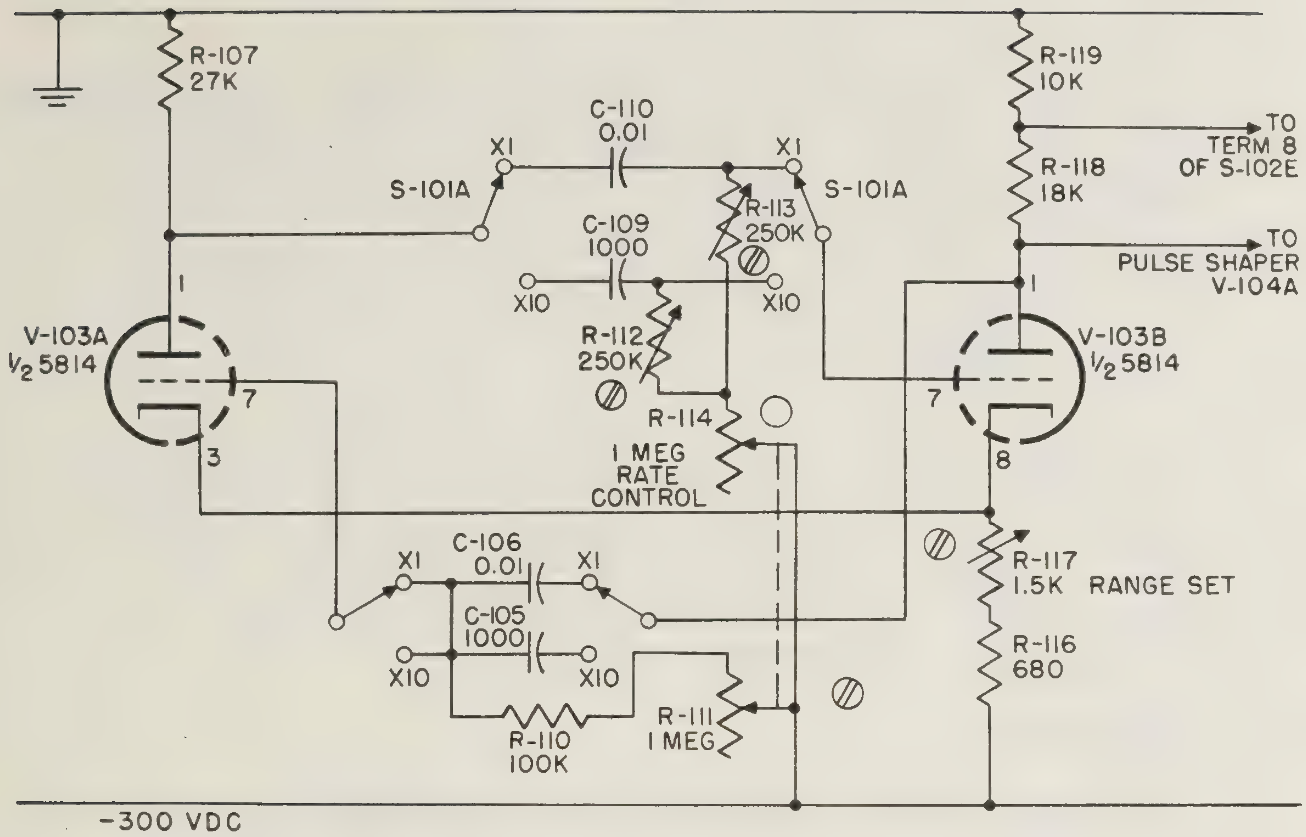


FIG. 3-19 BASIC PULSE RATE MULTIVIBRATOR

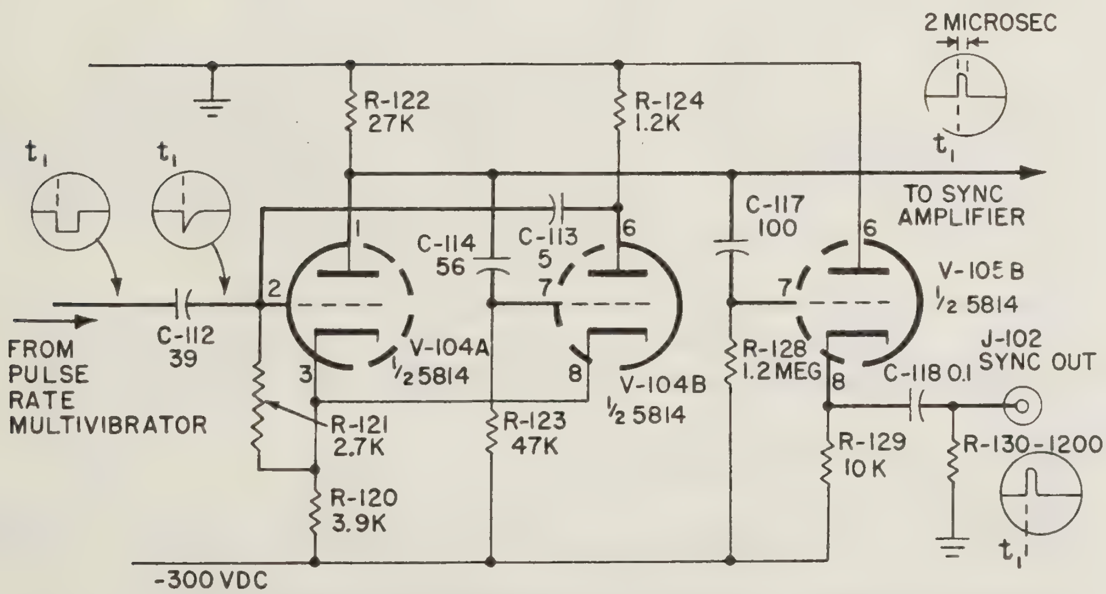


FIG. 3-20 PULSE SHAPING MULTIVIBRATOR AND SYNC OUT CATHODE FOLLOWER

The time constants of the multivibrator are balanced so that the circuit generates a wave that is essentially square (50% duty cycle). This arrangement is used so that internal square wave as well as internal pulse modulation of the r-f oscillator can be obtained. The arrangement also provides for equally-spaced pulses to trigger the sawtooth generator when internal sawtooth f-m modulation is desired.

A square wave voltage of full amplitude is taken from the plate across R-118 and R-119 for the pulse shaper while one of approximately one-third the amplitude is taken across R-119 for application to the modulator when the MOD SELECTOR switch is in the SQ WAVE position. This output to the modulator is employed only when square wave modulation is desired.

3-24 PULSE SHAPER.

The pulse shaper (figure 3-20) is a one-shot multivibrator with a two-microsecond time constant. It consists of V-104A and V-104B, two halves of a type 5814 dual triode. In the steady-state condition V-104A is drawing current as its grid is returned to the cathode by resistor R-121. V-104B is cut off as its grid is returned to -300 vdc, thus placing a bias on the grid developed by the flow of current through V-104A and cathode resistor R-120.

When this multivibrator is triggered by the negative going leading edge of the wave generated by the pulse rate multivibrator, a positive voltage pulse appears at the plate of V-104A. The pulse width is narrow, essentially two microseconds.

The positive output pulse is applied to the sync amplifier tube V-105A shown in figure 3-21 and to sync out cathode follower V-105B shown in figure 3-20.

3-25 SYNC OUT CATHODE FOLLOWER.

This stage provides the undelayed sync output signal for synchronizing external equipment. It is a standard cathode follower comprised of V-105B, one half of a type 5814 dual triode tube. The output is taken across R-129, the cathode resistor, and is capacitively coupled to the SYNC OUT connector J-102 by C-118. Resistor R-130 is returned from the center conductor of the connector to

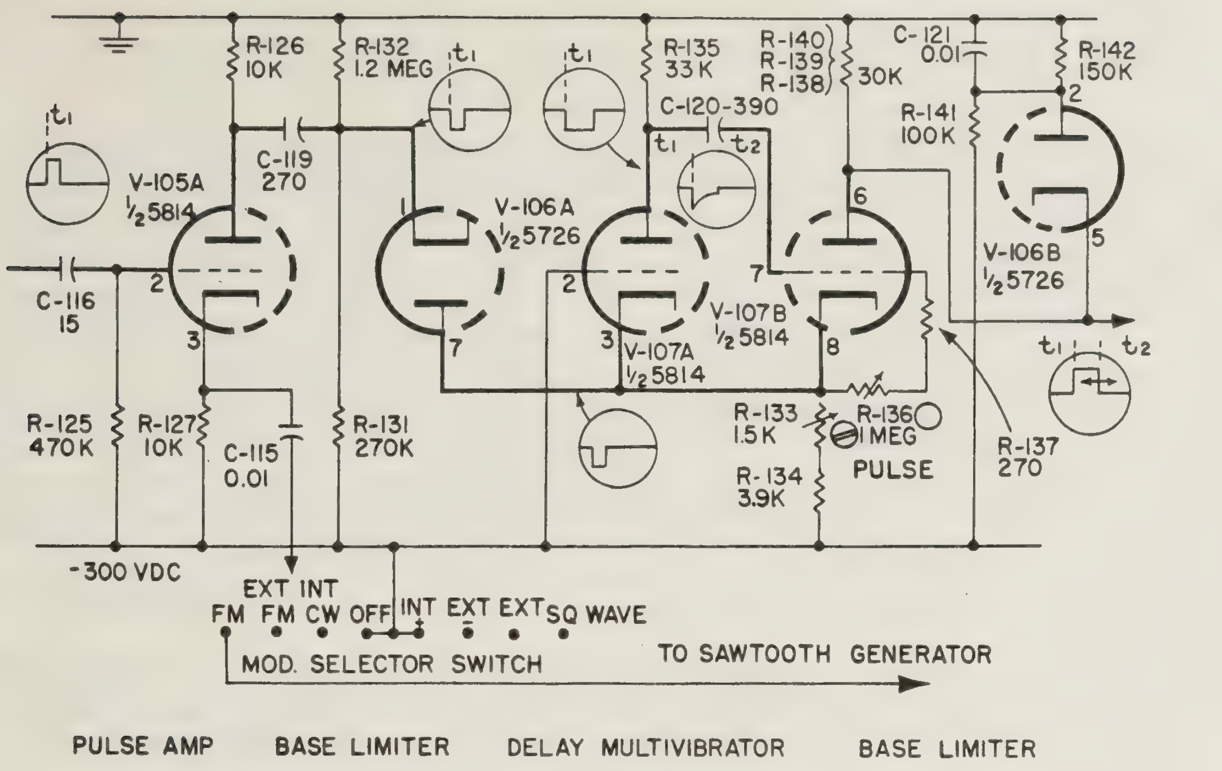


FIG. 3-21 PULSE AMPLIFIER AND DELAY MULTIVIBRATOR

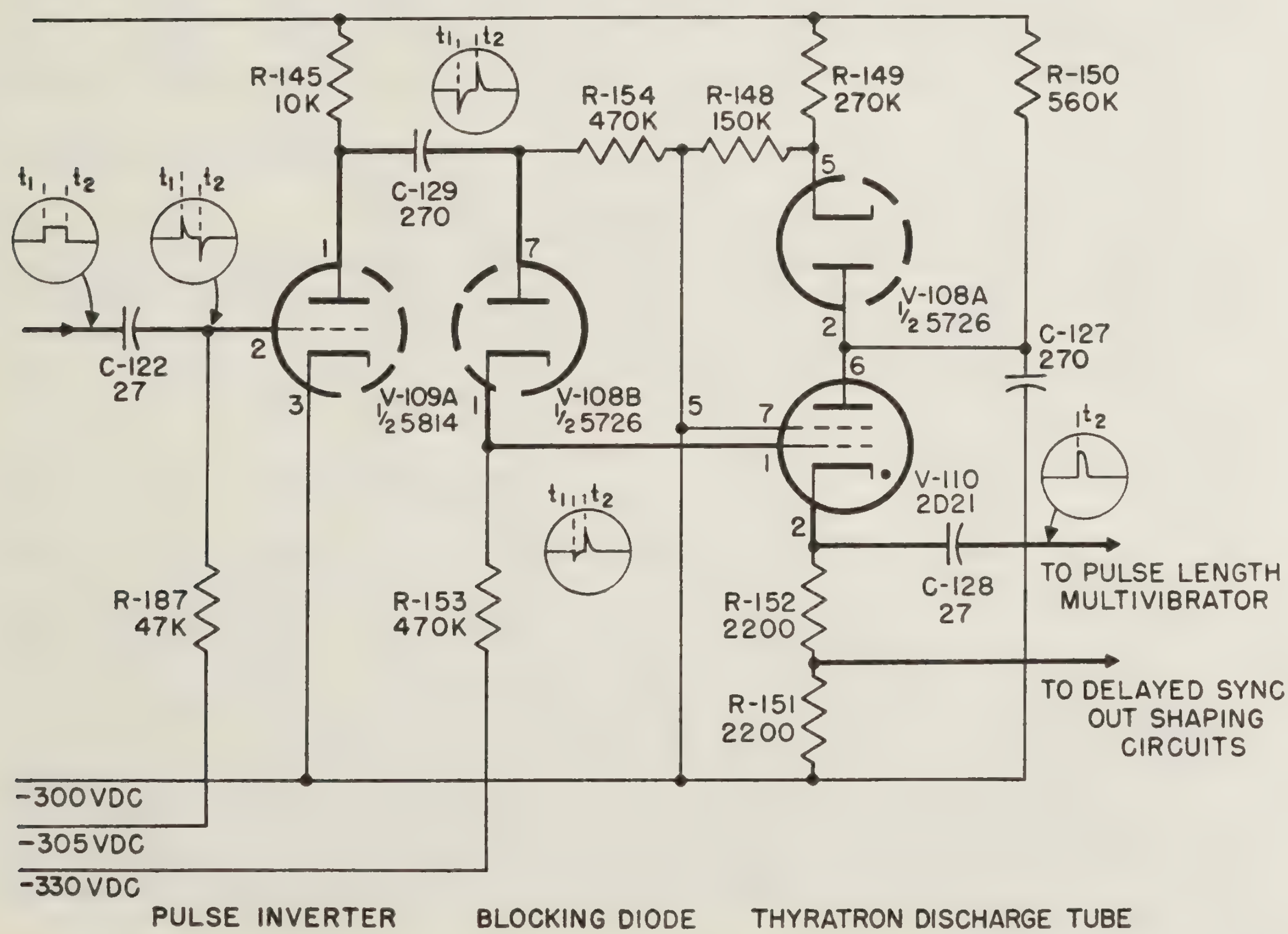


FIG. 3-22 THYRATRON DISCHARGE CIRCUITS

The multivibrator starts its cycle when a negative pulse drives the cathode of V-107A in a negative direction. This is equivalent to placing a positive signal on the grid, and the tube draws current. A negative wave front appears at the plate of V-107A and through capacitor C-120 drives the grid of V-107B in a negative direction, cutting off this half of the stage. The length of time the circuit will require before returning to its resting condition will be determined by the time constant of C-120, R-136 and R-137. R-136 is the calibrated PULSE DELAY panel control that adjusts the delay from 3 to 300 microseconds, while R-133 is a chassis adjustment used to set the maximum delay to 300 microseconds.

V-106B serves as a negative base limiter which eliminates low amplitude negative pulses that may otherwise follow the trailing edge of the main pulse from V-107B.

3-29. PULSE AMPLIFIER-INVERTER

This stage, shown in figure 3-22, is comprised of V-109A, one-half of a type 5814 dual triode. The positive pulse from the pulse delay multivibrator is differentiated by capacitor C-122 and resistor R-187 to form a sharp positive spike at t_1 and a negative spike at t_2. These are amplified and inverted in the plate circuit of V-109A.

3-30. BLOCKING DIODE.

The output of V-109A is applied to the grid of the thyratron discharge tube V-110 through blocking diode V-108B. The purpose of V-108B is to pass the positive output spike at t_2 and to block the negative spike at t_1. At short delays this insures positive triggering of the thyratron V-110.

3-31. THYRATRON DISCHARGE TUBE

This stage consists of the type 2D21 thyratron tube V-110 shown in figure 3-22. Its grid is returned to approximately -315 volts while the cathode is returned to -300 volts, cutting off the tube. Capacitor C-127 is charged to approximately 110 volts positive to the cathode, a point established by the values of R-148 and R-149 and diode V-108A. This device for limiting the voltage on C-127 is necessary due to wide variation in the pulse repetition frequency of the unit and the fact that the capacitor will charge exponentially with time.

ground so that the line is terminated in reference to ground instead of the 300 vdc potential existing at the base of the cathode resistor.

The output of the cathode follower is a positive pulse greater than 25 volts when applied to a load having a resistance of from 1000 to 100,000 ohms and a shunt capacitance of 500 mmf. At no load, the pulse will have an amplitude of up to 55 volts.

3-26. PULSE AMPLIFIER.

The pulse amplifier is comprised of V-105A, one-half of a type 5814 tube as shown in figure 3-21, and its associated components. It amplifies and inverts the two-microsecond pulse provided by the pulse shaper and provides a negative pulse at t_1 in its plate circuit. It also provides a positive-going pulse in its cathode circuit from C-115 that is employed to trigger the sawtooth generator when internal frequency modulation is employed. C-115 acts as a cathode bypass capacitor when internal pulse modulation is employed.

3-27. SERIES DIODE BASE LIMITER.

The negative pulse from the plate of the pulse amplifier is applied to the cathode of the diode limiter V-106A shown in figure 3-21. This limiter is so connected that only the negative components with an amplitude greater than the bias on the diode will pass on to the cathode of the delay multivibrator. This prevents triggering the multivibrator by any positive or low amplitude negative transients that may appear on the output of V-105A in addition to the desired trigger pulse.

3-28. DELAY MULTIVIBRATOR.

This circuit (figure 3-21) provides an adjustable time delay in applying the modulation to the r-f oscillator. It consists of the two sections of V-107, a type 5814 dual triode connected as a one-shot multivibrator with a time constant adjustable from 3 to 300 microseconds by R-136, the calibrated PULSE DELAY panel control.

In the steady-state condition V-107A is cut off while V-107B is drawing current through its plate load resistors R-138, R-139 and R-140 in parallel with R-142 and the diode V-106B.

This would result in the capacitor charging to a higher potential at the low repetition frequencies than at the higher frequencies. The diode circuit limits the charge to a value that can be reached at the highest repetition frequencies, and prevents it from going higher regardless of the charging time available.

When the positive pulse of voltage from V-109A reaches the grid, the gas in the tube ionizes and C-127 discharges through the tube, and cathode resistors R-157 and R-152 in series. This causes a positive pulse to appear across the cathode resistors.

When C-127 is nearly discharged and the plate voltage is at a very low value the gas in the tube deionizes and the tube returns to the resting condition. By this time the pulse on the grid has decayed and the grid bias is again -315 volts.

C-127 is rapidly recharged to its resting voltage of approximately 110 volts and is maintained at this value through the action of the diode circuit explained above.

The spike occurring in the cathode circuit at t_2 is applied to the pulse length multivibrator and to the delayed sync pulse output circuits.

3-32. <u>PULSE LENGTH MULTIVIBRATOR</u>.

The pulse length multivibrator shown in figure 3-23 is a one-shot multivibrator employing a type 5814 tube V-111. The circuit employs capacitive cathode to cathode coupling to secure the necessary interstage action. This avoids any feed-back connection to the plate of V-111A, reducing stray capacitance that would tend to slow down the voltage rise and fall. Peaking inductance L-101 is also employed in the plate circuit from which the output is taken to further steepen the wave front.

The section comprised of V-111A is cut off since a negative bias of 30 volts is placed on its grid. This places the V-111A side of C-130 at a potential of -300 volts. The second section is drawing saturation current since its grid is maintained at essentially the cathode voltage by R-162. As a result, the other side of C-130 is at a relatively higher potential due to the drop across R-158 and R-159.

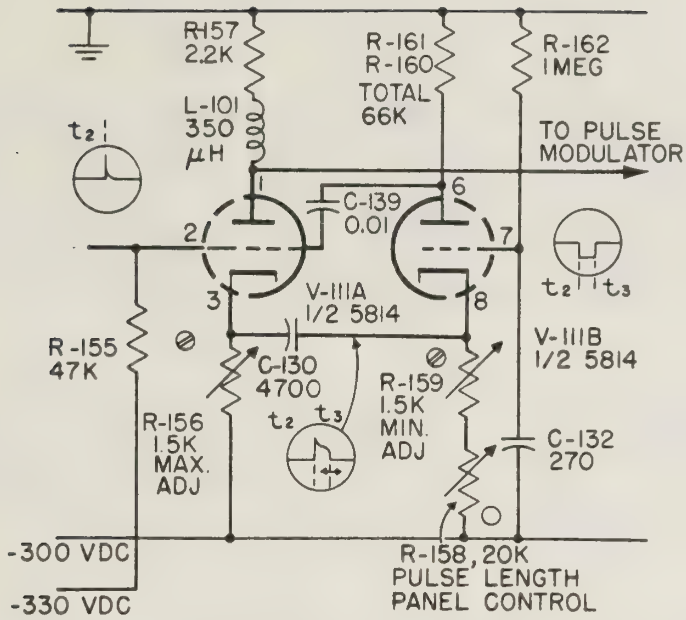


FIG. 3-23 PULSE LENGTH MULTIVIBRATOR

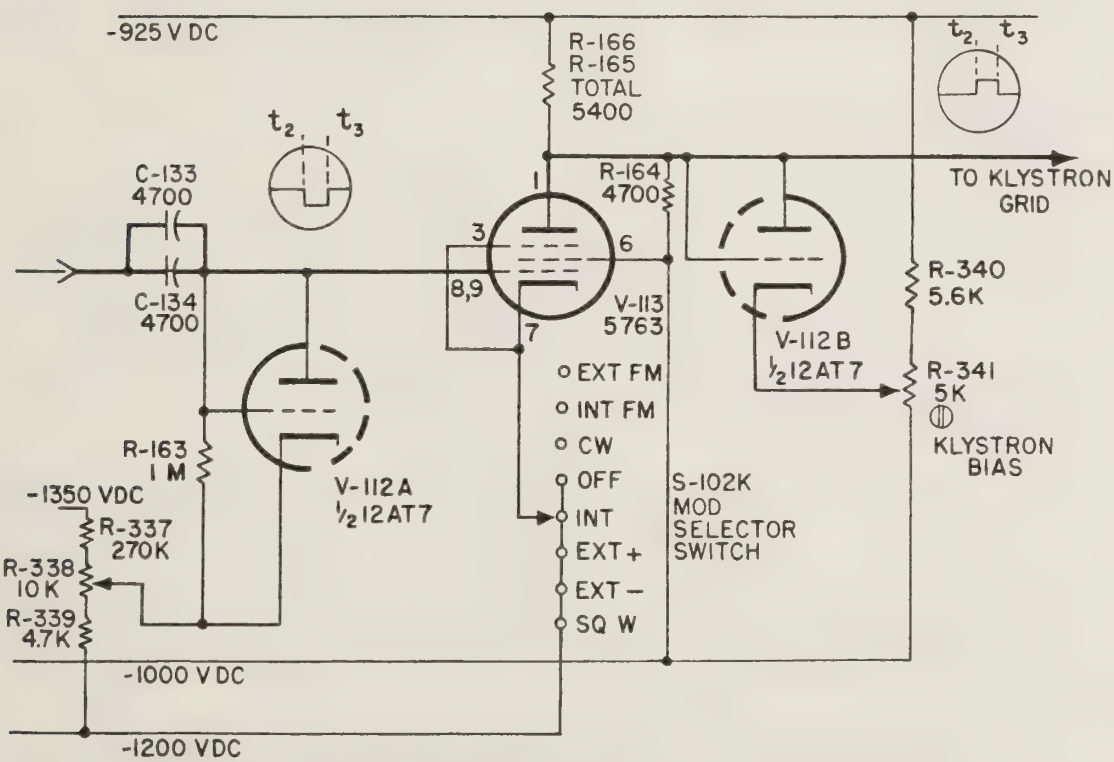


FIG. 3-24 KLYSTRON MODULATOR CIRCUIT

When the positive pulse at t_2 is applied to the grid of V-111A, it immediately draws current, causing the V-111A side of C-130 to rise to the potential set up by the current flowing through R-156. R-156 is adjustable, and the amount of this rise is determined by the resistance. R-156 acts as a maximum delay time adjustment for the circuit.

The voltage rise across R-156 is applied to the cathode of V-111B causing it to become more positive with respect to grid 7. This cuts off the tube rapidly since the grid is maintained at essentially the cathode potential due to the time constant of R-162 and C-132.

Capacitor C-130 is now charged in a positive direction and commences to discharge. The time constant of this discharge to the point where V111B will again draw current determines the duration of the negative output pulse. The minimum width is adjusted by R-159, a screwdriver control on the chassis, while R-158 is the calibrated PULSE WIDTH panel control. This control can be adjusted to provide pulses of from 0.5 to 10 microseconds duration.

The output of the pulse length multivibrator is a negative pulse starting at t_2 and ending at t_3. This negative pulse is applied to the pulse modulator tube V-113.

3-33. KLYSTRON MODULATOR

The klystron modulator circuits shown in figure 3-24 are comprised of V-113, a type 5763 pentode amplifier, and V-112A, one-half of a type 12AT7 dual triode connected as a diode positive peak clipper. V-112B, the other half of the type 12AT7 dual triode, diode-connected, provides a fixed operating bias for the accelerator grid of the klystron r-f oscillator tube V-114.

The positive pulse from the pulse width multivibrator is coupled to the control grid of V-113 by C-133 and C-134 in parallel. Bias for the grid is adjusted by potentiometer R-338 in the power supply, so that the flow of current in the modulator is sufficient to cut off the klystron.

The adjustment of R-341 determines the maximum positive voltage applied to the grid of the klystron when the modulation pulse is present.

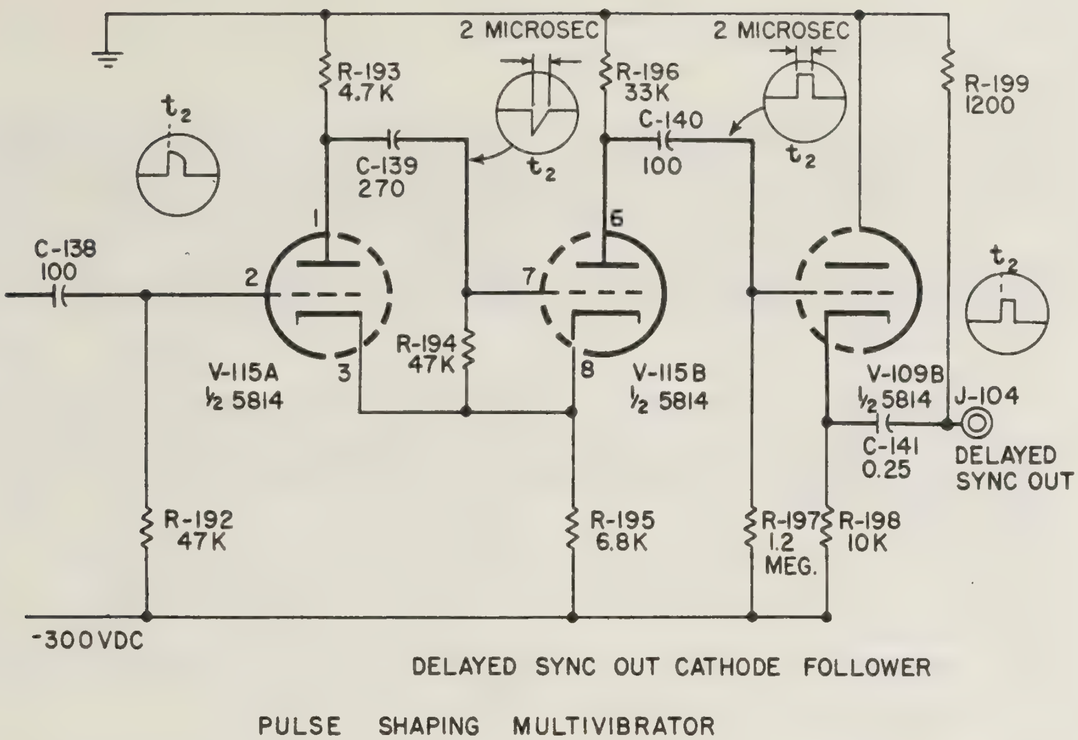


FIG. 3-25 PULSE SHAPING MULTIVIBRATOR AND DELAYED SYNC OUT CATHODE FOLLOWER

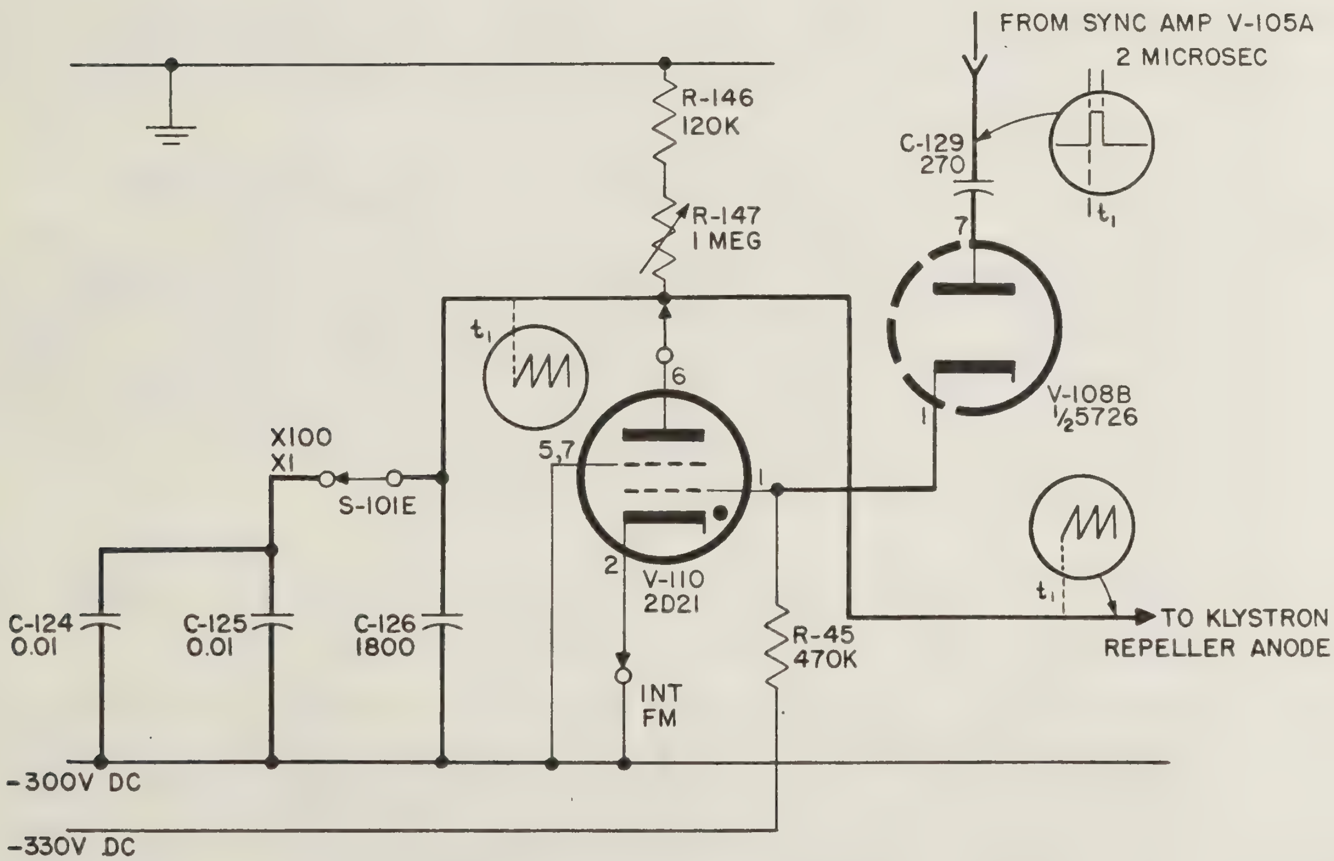


FIG. 3-26 INTERNAL FREQUENCY MODULATING CIRCUIT

When the negative pulse starting at t_2 and terminating at t_3 appears on the control grid of V-113, the grid is driven to cutoff. The voltage at the plate tends to rise instantly to -925 volts since current flow through its plate resistors is cut off. However, when it crosses the voltage value established by the setting of R-341, the diode plate becomes positive with respect to the cathode. Current will then flow through the diode, limiting the positive excursion of the voltage at the grid of the klystron tube to the bias established by the setting of R-341.

At the termination of the negative pulse at t_3 the voltage at the grid of V-113 rises, permitting the tube to again draw current. Any positive transient existing at t_3 will be clipped by diode V-112A.

At the same time (t_3) the voltage at the plate of V-113 will drop, since it will start drawing plate current through its plate resistors. Flow of current through V-112B will be blocked at the instant the plate voltage drops below the point established by the adjustment of R-341, and the voltage applied to the grid of the klystron will cut off oscillations in the r-f oscillator.

The modulator tube, in the manner just described, provides an optimum positive output to the modulation grid of the r-f oscillator tube to permit it to oscillate during the period between t_2 and t_3.

3-34. DELAYED OUTPUT PULSE SHAPER AND CATHODE FOLLOWER.

(See figure 3-25.) The delayed output pulse shaper is a multivibrator comprised of the two triode sections of the type 5814 tube V-115. One half the type 5814 dual triode tube, V-109B, is connected as a cathode follower. The positive spike developed in the cathode circuit of the thyratron discharge tube is applied to grid of V-115A through capacitor C-138 at time t_2.

The section of the multivibrator formed by V-115A is cut off, its negative bias being established by current of V-115B flowing through cathode resistor R-195.

The section comprised of V-115B is drawing current in the resting condition as its grid is returned to the cathode through R-194. The positive leading edge of the pulse from V-110 causes the multivibrator to switch, cutting off current through V-115B and causing the voltage at its plate to rise.

The time constant of the circuit is approximately two microseconds. At the end of this time capacitor C-139 is discharged through R-194 and R-195 to a point where V-115B again draws current and completes the cycle. The output at the plate of V-115B is a positive pulse of two microseconds duration. This is coupled to V-109B, the cathode follower.

V-109B is a conventional cathode follower employed as an impedance transformer, receiving the pulse from the high impedance plate of the multivibrator and delivering it to the relatively low impedance across the DELAYED SYNC OUT panel connector J-104 for synchronizing external equipment at t_2.

3-35. INTERNAL FREQUENCY MODULATION

When the MOD SELECTOR switch S-102 is in the INT FM position, the thyratron discharge tube is switched to comprise a conventional relaxation oscillator as shown in figure 3-26. This oscillator develops a sawtooth voltage wave that is applied to the r-f oscillator repeller.

C-124, C-125 and C-126 with resistors R-146 and R-147 determine the time constant of the sawtooth output for the X1 range while C-126, R-146 and R-147 perform the same function for the X10 range. R-147 is ganged with R-111 and R-114 and adjusted by the calibrated PULSE RATE panel control so that the f-m sweep rate and the internal pulse repetition rate may be controlled by the same knob.

The relaxation oscillator is triggered by a positive pulse from the cathode of the pulse shaper and when activated, delivers a rising sawtooth voltage to the repeller, sweeping the frequency and providing sawtooth frequency modulation.

AIR FILTER REPLACEMENT

An air cleaner element is located just inside the louvres on the back of the instrument cabinet. Air is drawn into the cabinet through this cleaner and is exhausted through the vent in the left side of the cabinet. It is important that this cleaner be changed sufficiently often to assure adequate and clean ventilation. The life of the klystron will be shortened if the air flow is reduced by a dirt clogged filter.

To replace the cleaner element first remove the instrument from the cabinet as described below. Then remove the two round head machine screws on back side of cabinet which hold the clamp over one corner of the cleaner element. The element may now be removed and replaced.

TO REMOVE CABINET

The fit between the cabinet and instrument is intentionally tight. Removing the cabinet is a two-man job.

Place instrument panel down on a low surface (floor or low table) so that it rests on the guard-rail handles. Unscrew the four knurled captive screws on back of the cabinet (now facing up) until the threads are free of the instrument. The screws will not come out of the cabinet. Cabinet is now free to be lifted off instrument.

TO REPLACE CABINET

To replace cabinet, again place instrument with panel down. Care must be taken to prevent the rubber baffle on side of instrument from being folded over by the edge of the cabinet. This will require placing a sheet of thin metal or cardboard between the baffle and the cabinet until the edge of the cabinet passes over the baffle.

SECTION IV

SERVICE INSTRUCTIONS

WARNING

Be careful when making voltage measurements. High voltages (1500 volts) which may be fatal upon contact are present in certain portions of the equipment. The positive sides of two of the power supplies are at chassis (ground) potential, while in the third, both the positive and negative sides are removed from ground potential. Be especially careful when making measurements in which neither the positive nor negative side of the meter is at chassis or ground potential. In such cases, and in ALL HIGH VOLTAGE measurements, turn the equipment OFF before attaching meter. After the measurement turn equipment OFF before disconnecting meter.

4-1. TUBE REPLACEMENT AND ADJUSTMENTS REQUIRED

The tubes used in Signal Generator TS-621/U are listed in the following table; the physical location of the tubes is indicated by figure 4-1. Replacing those tubes indicated by asterisks (e.g., V-103*) in the following table may require adjustment of internal controls to obtain optimum performance of the equipment. The adjustment procedures are described on the following pages.

TABLE 4-1. TUBE COMPLEMENT, SIGNAL GENERATOR TS-621/U

Tube	Type	Function	Replacement Adjustments
V-101	JAN-12AT7	Sync Amplifier and Inverter	None
V-102	5726	Clipper (1/2 tube not used)	None

TABLE 4-1. TUBE COMPLEMENT, SIGNAL GENERATOR TS-621/U (cont.)

Tube	Type	Function	Replacement Adjustments
V-103*	5814	Rate Multivibrator	Par 4-2
V-104	5814	Pulse Shaping Multivibrator	None
V-105	5814	Pulse Ampl and Sync Out Cathode Follower	None
V-106	5726	Base Limiter for Delay Multivibrator	None
V-107*	5814	Delay Multivibrator	Par 4-3
V-108	5726	Blocking Diode	None
V-109	5814	Pulse Ampl-Inverter and Delayed Sync Out Cathode Follower	None
V-110	JAN-2D21	Thyratron Discharge Tube	None
V-111*	5814	Pulse Width Multivibrator	Par 4-4
V-112*	JAN-12AT7	Clipper and Klystron Bias Regulator	Par 4-5
V-113*	5763	Modulator	Par 4-5
V-114*	6236	Radio Frequency Oscillator	Par 4-6, 4-7 4-8, 4-9
V-115	5814	Delayed Sync Out Multivibrator	None
V-301	JAN-5R4GWY	Full Wave Rectifier	None

*See text for replacement procedure

TABLE 4-1. TUBE COMPLEMENT, SIGNAL GENERATOR TS-621/U (cont.)

Tube	Type	Function	Replacement Adjustments
V-302*	JAN-6AU6	Regulator Amplifier	Par 4-11
V-303*	JAN-6AS7	Series Regulator	Par 4-11, 4-12
V-304*	JAN-OA2	Voltage Regulator	Par 4-11
V-305	JAN-5R4GWY	Full Wave Rectifier	None
V-306*	JAN-6AU6	Regulator Amplifier	Par 4-12
V-307	JAN-5R4GWY	Full Wave Rectifier	None
V-308*	JAN-6AS7	Series Regulator	Par 4-13
V-309*	JAN-6AU6	Regulator Amplifier	Par 4-13
V-310*	JAN-OA2	Voltage Regulator	Par 4-13
V-311*	JAN-OA2	Voltage Regulator	Par 4-13
V-312*	JAN-OA3	Voltage Regulator	Par 4-13
V-313*	JAN-OA2	Voltage Regulator	Par 4-14
V-314*	JAN-OA2	Voltage Regulator	Par 4-14

* See text for replacement procedure

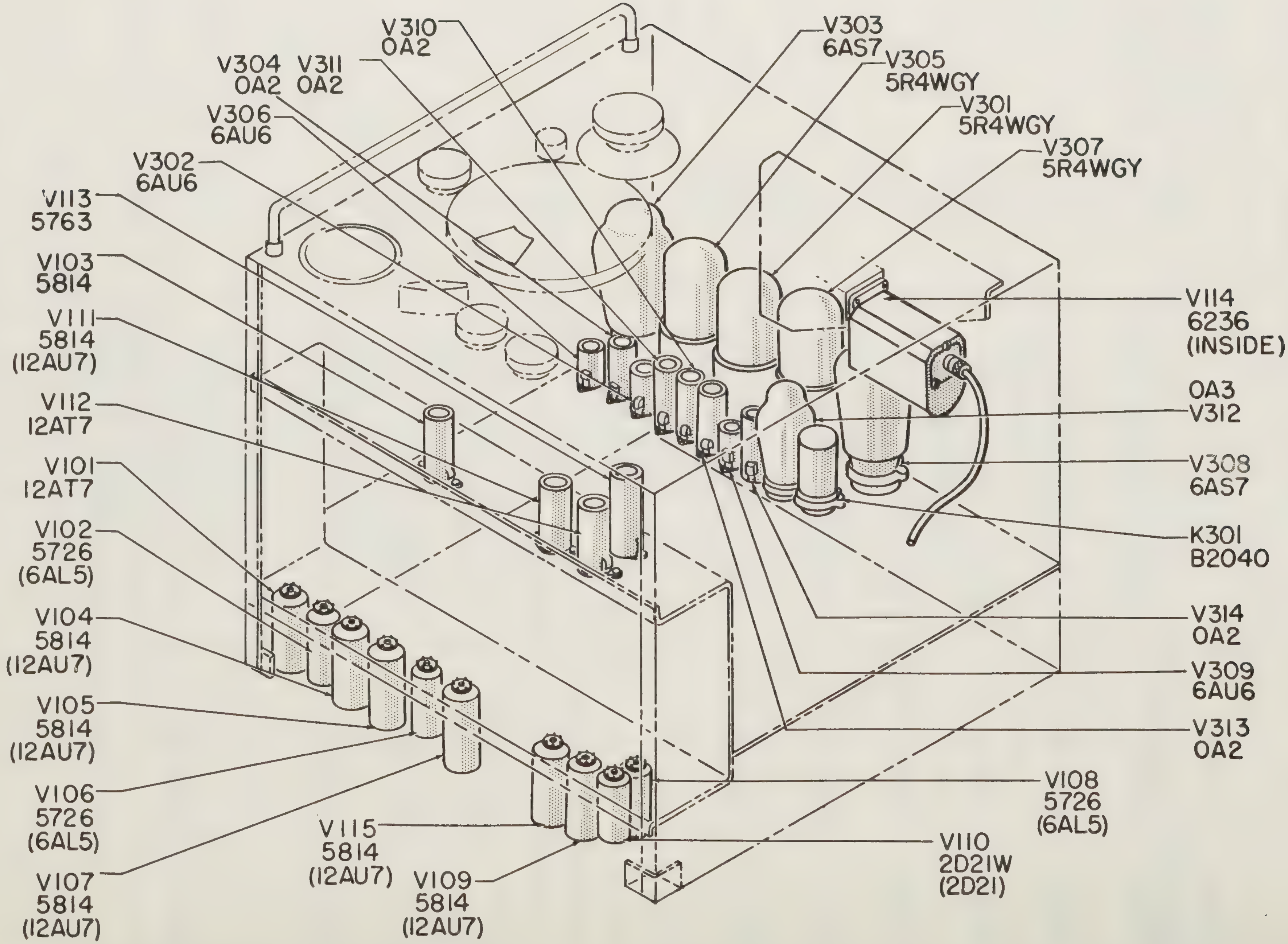


FIG. 4-1 TUBE LOCATION DIAGRAM

4-2. REPLACING V-103

Replacing V-103 may lessen the accuracy of the PULSE RATE dial but will not otherwise affect the performance of the signal generator. It should be noted, however, that the calibration of this dial is only approximate and at some dial points the error may be as much as 25%.

To calibrate the PULSE RATE dial after replacing V-103, proceed as follows:

a. Connect SYNC OUT connector to the trigger input of an oscilloscope.

b. Connect DELAYED SYNC OUT connector to the oscilloscope vertical amplifier input.

c. Connect the output of a calibrated audio oscillator to the oscilloscope vertical amplifier input through a 10,000-ohm isolating resistor.

d. Set the MOD SELECTOR switch to INT. and the pulse rate to 4000 pps (SYNC SELECTOR switch to X10 and PULSE RATE control to 400).

e. Adjust the amplitude controls on the oscilloscope and oscillator to obtain a convenient scope presentation.

f. Set the oscillator to 4000 cps.

g. Adjust the sweep rate of the oscilloscope so that several cycles of sine wave occupy the full width of the screen.

h. Adjust R-112 so that the generated pulse rate is 4000 pps. When the repetition rate of the pulses is 4000 pps, each pulse will be superimposed upon each cycle of the sine wave. Adjust R-112 until the pattern is stationary and all slope is removed (top of pulses in a straight, horizontal line).

i. Set the SYNC SELECTOR switch to X1 with the other controls remaining unchanged. Set oscillator to 400 cps.

j. Adjust R-113 so that the generated pulse rate is 400 pps.

k. Set the PULSE RATE control to 40 pps, with the other controls remaining unchanged. Set oscillator to 40 cps.

l. Adjust R-117 so that the generated pulse rate is 40 pps.

m. Set SYNC SELECTOR switch to X10 and check the calibration of the PULSE RATE dial in vicinity of 40. R-117 can be readjusted to improve calibration accuracy if desired.

n. Repeat complete procedure, making any desired refinements in adjustment.

4-3. REPLACING V-107

Replacing V-107 may lessen the accuracy of the PULSE DELAY dial. After replacing V-107, the following procedure can be used to adjust the delay calibration. However, the calibration of the PULSE DELAY dial is intended only to be approximate.

a. Connect DELAYED SYNC OUT to the vertical input of an oscilloscope having an accurately calibrated sweep.

b. Synchronize the oscilloscope from the SYNC OUT connector.

c. Set PULSE DELAY control to 300 microseconds.

d. Adjust R-133 to give a delay of 300 microseconds as measured on the oscilloscope sweep.

e. Set PULSE DELAY control to 3 microseconds. If necessary, slip the PULSE DELAY dial on its shaft to make calibration accurate. The delay is indicated by the interval between the start of the oscilloscope trace and the leading edge of the Delayed Sync Out pulse appearing on the oscilloscope.

f. Repeat steps c and d for best overall calibration.

4-4. REPLACING V-111

Replacing V-111 may lessen the accuracy of the PULSE WIDTH dial which is intended to be accurate within 20% or 1 microsecond, whichever is greater. The following procedure can be used to adjust the calibration of the dial.

a. Connect RF OUTPUT through a crystal detector to the vertical input of an oscilloscope having an accurately calibrated sweep.

b. Synchronize the oscilloscope from the SYNC OUT connector.

c. Set the PULSE WIDTH control to 10 microseconds.

d. Adjust R-156 so that the width of the generated pulse is 10 microseconds as measured on the oscilloscope.

e. Set the PULSE WIDTH control to 0.5 microsecond.

f. Adjust R-159 so that the width of the pulse is 0.5 microsecond.

g. The width of the r-f pulse will vary approximately 1/4 microsecond as the generator is tuned through its r-f range. The above adjustments can be made for best accuracy at any desired r-f frequency.

4-5. REPLACING V-112 and V-113

When either V-112 or V-113 are replaced, it is necessary to check and/or adjust the klystron control grid cutoff voltage and beam current. This is done as follows:

a. To adjust the cutoff bias, place the MOD SELECTOR switch in the OFF position.

b. Connect a high-resistance voltmeter between pin 3 of V-303 and chassis.

c. Adjust R-338 until the voltage is a minimum (approximately 0.1 volt).

d. Place MOD SELECTOR switch in the "CW" position.

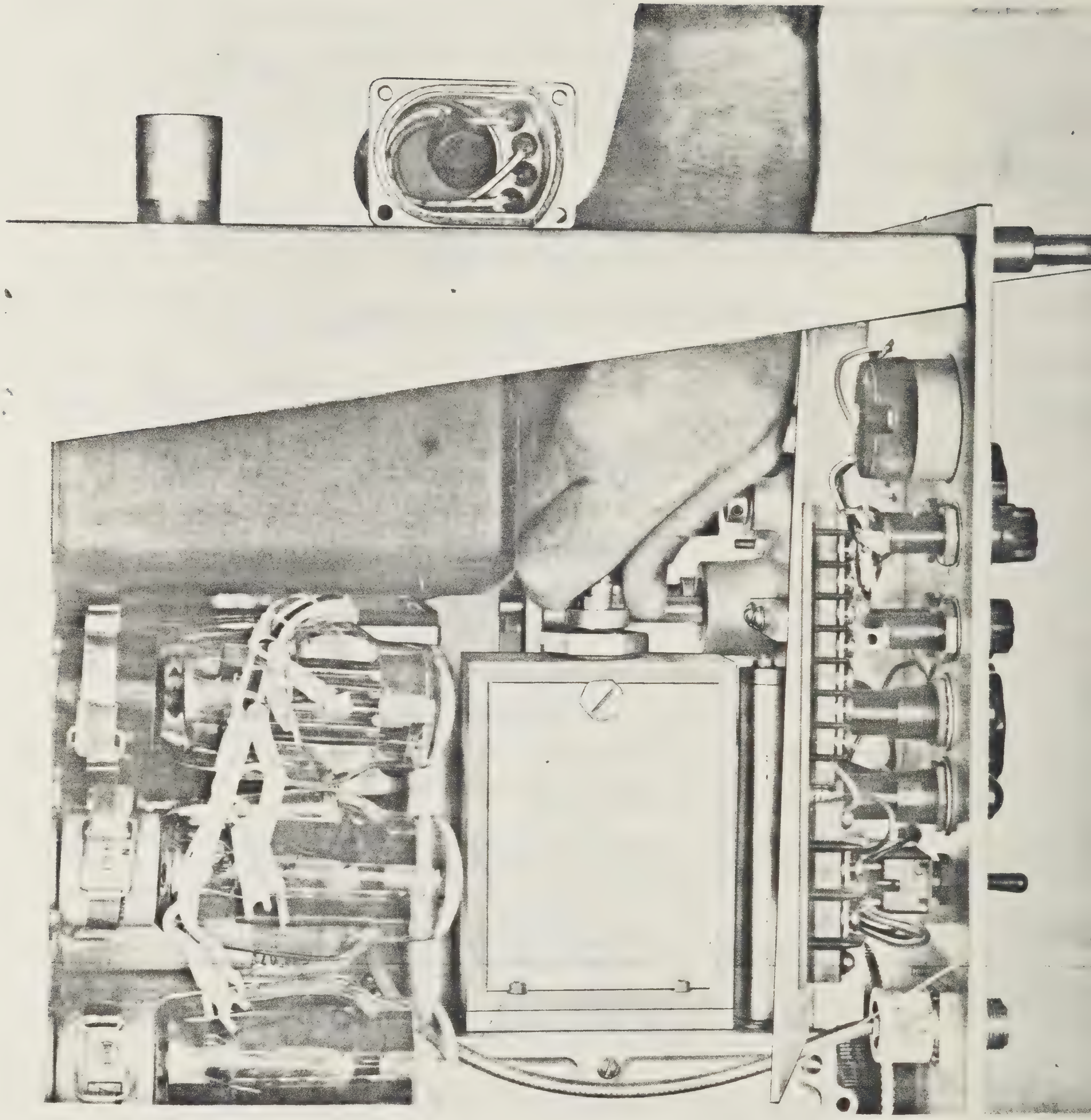


FIG. 4-2 SIGNAL GENERATOR TS-621/U IN POSITION FOR KLYSTRON REPLACEMENT

e. Adjust R-341 until the voltmeter reads 2 volts, which corresponds to a klystron beam current of 20 milliamperes. This value may be varied between 1.8 and 2.2 volts to give best operation of the klystron throughout the r-f frequency range when square-wave modulated.

4-6. REMOVAL OF KLYSTRON (V-114)

To remove the klystron from the resonator:

a. Place the signal generator with the cover removed in the position shown in figure 4-2 for ease in reaching the tube.

b. Remove the socket housing cap screws and lock washers (items 1 and 2, figure 4-3) with the large key wrench located in the Fahnstock storage clip to the rear of the chassis. Pull the housing (item 3, figure 4-3) back until the tube socket is exposed.

c. Pull straight back on the socket until it is free of the tube base. Be very careful NOT TO APPLY LATERAL PRESSURE when removing socket.

d. Unscrew and remove the sleeve (4) that covers the body of the klystron tube. Be careful not to push the klystron sideways in the cavity.

e. Turn the tube (6) clockwise and at the same time pull straight back, removing it from the cavity. Do not attempt to rock the tube or move it sideways. To do so may break the glass seals of the tube.

f. Remove semi-circular sections of the clamping ring.(5)

g. Unscrew the hex nut (7) at the entrance to the cavity, using socket wrench stowed beside tubes on pulser deck. Remove the spring (8) below the hex nut. Do not re-use this same spring except in an emergency. New springs are supplied with the equipment and are located in plastic envelopes inside transit case.

h. If the cavity ventilating pipe connector (tuning plug) protrudes into the cavity, remove connector nut and disengage pipe. Loosen set nut and back out the adapter until it is flush with the inside face of the cavity bottom plate.

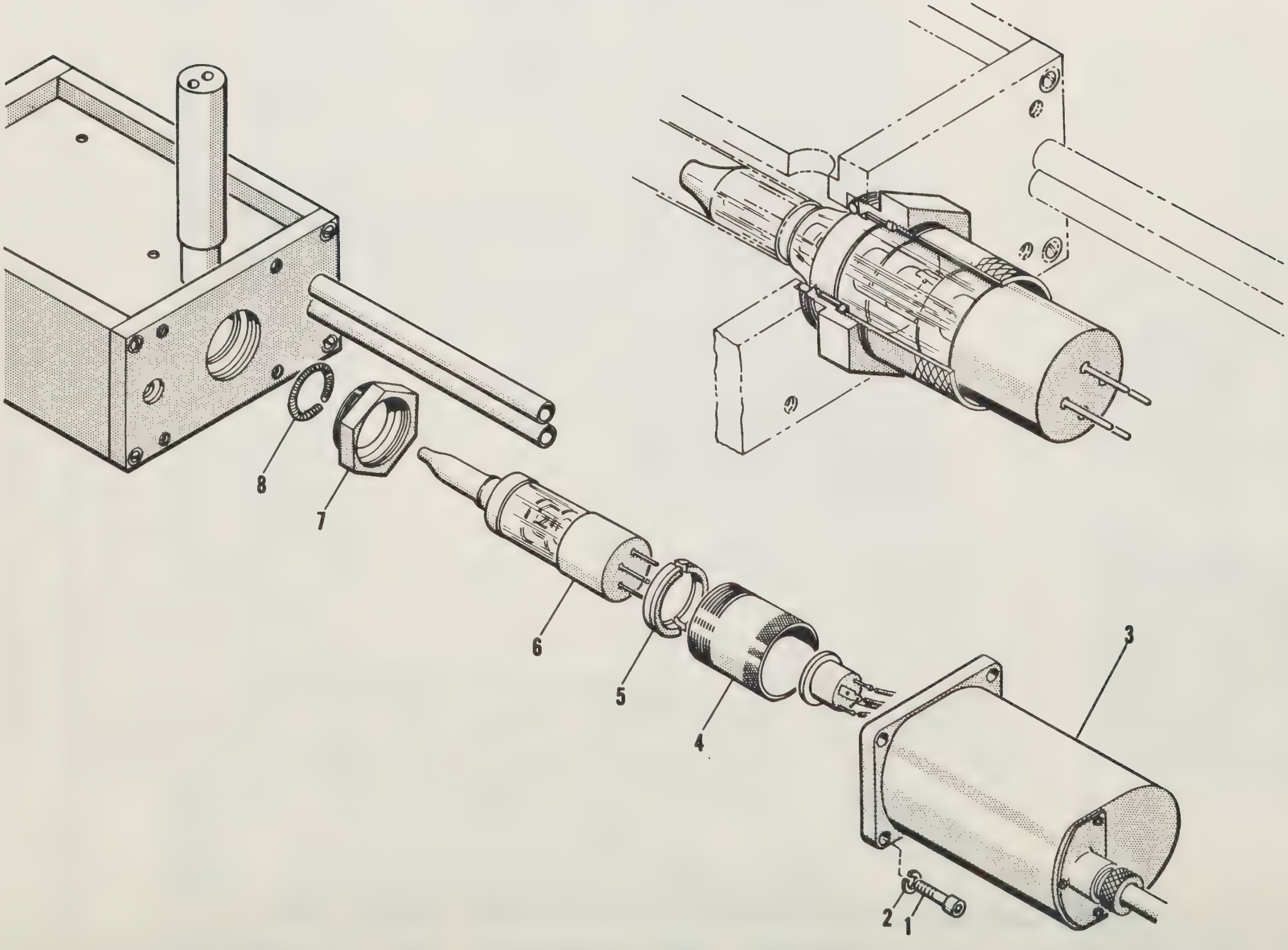


FIG. 4-3 EXPLODED VIEW OF KLYSTRON MOUNTING PARTS

4-7. INSTALLING KLYSTRON V-114

Prior to installing a new klystron V-114, practice reinstalling the old klystron. The proper force and twist required to push the klystron past the spring may then be learned by practice. The procedure for installing the new klystron V-114 is as follows: (See figure 4-3)

a. Install new spring (8) in entrance to the cavity so that the ends meet and form a complete circle.

b. Thread hex nut (7) into cavity until it is seated very lightly against the spring. Press the spring back under the nut all around so that the spring forms a perfect circle. Tighten the nut very slightly to hold the spring in this position.

CAUTION

> When inserting the tube, always keep it straight in line with the cavity. Never work it from side to side. To do so may damage the glass seals of the tube.

c. Observing the above caution, insert the klystron tube (6) into the cavity and push it forward until it engages the spring (8). Then, firmly press the tube straight into the cavity, at the same time giving it a clockwise twist. This will cause the tube to expand the spring slightly and to slide past the spring and seat firmly against the cavity. Practice with the old klystron will give the proper feel to determine when the tube is properly installed.

d. Tighten the hex nut moderately with socket wrench supplied.

e. Insert the split clamping ring (5) making certain that the sections of the ring encircle the grid ring of the tube which can be seen just inside the hex nut. When the ring is in the proper position, three or four threads of the nut (7) should be visible between the clamping ring and the outside face of the nut.

f. Thread the cover sleeve (4) into the hex nut so that it seats against the clamping ring, causing the ring

to grip the klystron grid ring. Tighten the sleeve (4) firmly by hand.

g. Install the tube socket and housing (3), pressing the socket <u>straight</u> onto the tube.

h. Position the socket housing and attach with the four Allen cap screws (1) originally removed and tighten with the key wrench.

4-8. ADJUSTMENTS FOLLOWING REPLACEMENT OF KLYSTRON V-114

Following replacement of V-114 it is important that certain adjustments be made as soon as the signal generator is turned on. The following procedure is recommended.

a. With MOD SELECTOR switch on OFF, turn on signal generator with new V-114 installed.

b. Check the voltage of the -1000 volt supply as described in paragraph 4-12.

c. Check the voltage of the -500 volt supply as described in paragraph 4-13.

d. With the MOD SELECTOR switch set to CW, adjust the klystron beam current to 20 ma as described in paragraph 4-5.

e. With the MOD SELECTOR switch set to OFF, adjust the klystron cutoff bias as described in paragraph 4-5.

f. With MOD SELECTOR switch on CW tune signal generator to 7400 mc.

g. Adjust R-170 (on frequency drive casting) for peak power output as observed on the POWER LEVEL meter.

h. Reduce peak power output about one db by re-adjusting R-170. This reduction should be made on the "slow" side of the peak; that is, on the side for which the power output decreases more slowly as R-170 is rotated.

i. Tune signal generator to 4400mc.

j. Adjust R-173 and/or R-178 described in steps <u>g</u> and <u>h</u> above.

k. Tune signal generator to 3800 mc.

l. Adjust R-175 as described in steps g and h above.

m. Repeat above adjustments as there is some degree of interaction, particularly between the 4400 and 3800 mc adjustments.

n. Connect RF OUTPUT to the vertical amplifier of oscilloscope through a suitable crystal detector.

o. Observe square wave operation throughout entire r-f frequency range. Should any weak or unstable points be noticed, slightly readjust repeller voltage by means of R-170, R-173, and R-175 for best operation. If operation is not improved, adjust klystron beam current by means of R-341 as described in paragraph 4-5.

4-9. FREQUENCY CALIBRATION

Replacing the klystron will usually reduce the accuracy of the MEGACYCLES dial by several per cent from its rated accuracy of 1%. If accuracy of frequency calibration is important, the following procedure can be used to restore accuracy. This procedure requires use of a frequency meter which covers the range of the signal generator and which is accurate within at least 1%.

a. Set MOD SELECTOR switch to CW. The equipment should be allowed a warm-up of at least 20 minutes before checking calibration.

b. Tune signal generator to 7650 on MEGACYCLES dial.

c. Measure output frequency with frequency meter. If reading of MEGACYCLES dial is in error by more than approximately 100 megacycles, it will be necessary to remove plate that covers frequency drive assembly.

d. With MEGACYCLES dial still set at 7650, loosen set screws holding resonator plunger rods in drive bar. Then manually move plunger rods in approximately 1/32" steps until output frequency is approximately 7650 megacycles as indicated by frequency meter. Tighten set screws in drive bar in this position.

e. Tune MEGACYCLES dial to 7500. Measure output frequency with frequency meter. If output frequency does not agree with dial within 1%, adjust ventilating pipe connector (which serves as tuning plug) on resonator to obtain desired accuracy.

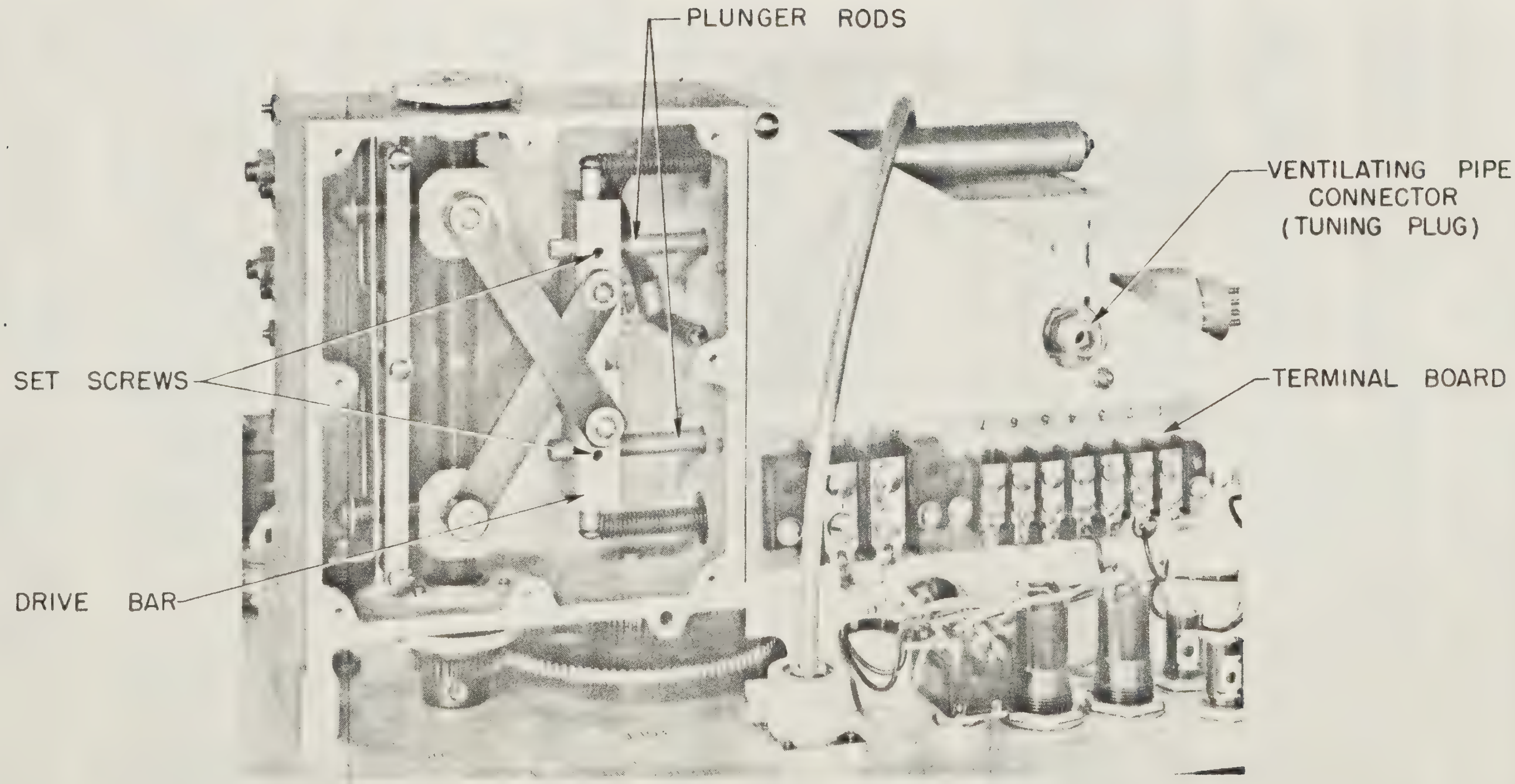


FIG. 4-3a FREQUENCY DRIVE ASSEMBLY, BOTTOM VIEW

f. Check calibration of MEGACYCLES dial through range of generator. If accuracy at lower frequencies is outside 1% tolerance, the dial can be slipped slightly on its shaft to obtain desired accuracy at lower frequencies. Calibration at higher frequencies can then be restored with tuning plug.

g. It may not be possible to achieve 1% overall accuracy with some replacement klystrons. In such case try another klystron and repeat procedure.

4-10. POWER SUPPLY SERVICING

In general, power supply trouble will show up as poor or unstable performance in all positions of the MOD SELECTOR switch. Measure all output voltages from power supply. Refer to voltage diagram, figure 4-5. Check tubes and replace any which appear doubtful.

When replacing tubes in the power supply section of the signal generator it must be remembered that the three power supplies are all regulated and inter-dependent, each using another as a reference point, and that the positive sides of two of the supplies are at ground potential and that of the third is 925 volts negative to ground.

A change in the output of the -300 volt supply in turn changes the output voltage of the -1000 volt supply. One half of V-303 is used in both the -300 and -1000 volt supplies; thus both supplies must be checked following its replacement.

To check the regulation of the power supplies following replacement of any tube therein, connect the signal generator power cord to a variable autotransformer. Set the MOD SELECTOR switch to CW.

Adjust the voltage applied to the instrument between 104 and 126 volts while measuring the output voltage of the regulated supply in question. The regulated voltages may vary ±1% with a line voltage change from 104 to 126 volts. The hum level should be less than 30 millivolts with the same line voltage variation.

4-11. <u>REPLACING V-302, V-303 and V-304</u>

Following replacement of V-303, or V-304:

a. Connect a high resistance d-c voltmeter across the terminals of capacitor C-304, with the positive lead of the voltmeter on the grounded terminal of capacitor C-304.

b. Adjust R-307 until the voltage is exactly -300 volts.

c. Check, and if necessary reset -1000 volt supply as described in paragraph 4-12.

4-12. <u>REPLACING V-303 and V-306</u>

Following replacement of V-303 or V-306:

a. Connect the negative lead of a high resistance d-c voltmeter to the -1000 volt buss (9 of the terminal board under resonator) and the positive lead to ground.

b. Adjust R-320 until voltage is exactly -1000 volts.

4-13. <u>REPLACING V-308, V-309, V-310, V-311 and V-312</u>

When replacing any one of these tubes:

a. Connect the negative lead of a high resistance d-c voltmeter to terminal 8 of the terminal board under resonator (-1500 volts) and the positive lead to terminal 9 (-1000 volts).

b. Adjust R-335 until the meter indicates exactly -500 volts.

c. Following replacement of V-312 check klystron operating current as described in paragraph 4-5.

4-14. <u>REPLACING V-313 and V-314</u>

When replacing either of these tubes:

a. Connect the negative lead of a high resistance d-c voltmeter to chassis and the positive lead to pin 3 of V-303.

b. Adjust R-338 until the voltage across resistor R-316 measures 0.1 volt or less. (See paragraph 4-5)

4-15. ATTENUATOR ASSEMBLY

Power from the resonator is coupled to the RF OUTPUT jack at the front panel through an assembly consisting of the panel jack, a length of RG-55/U cable, and the attenuator probe. Inside the attenuator probe is a special resistor, R-202, which consists of a platinum-coated glass rod 0.03 inch in diameter. This resistor should normally last for the life of the equipment even if subjected to shock and vibration.

Should the resistor become broken or otherwise defective however, the complete attenuator assembly must be replaced. The ASO stock number for the replacement assembly is R16HWP-618BM114. Other service stock numbers will be assigned at a later time.

If the glass rod becomes broken, the following two symptoms will usually be present:

(1) No r-f output will be obtained.

(2) The d-c resistance between the center pin of the RF OUTPUT connector and ground will be very large. If the glass rod is not defective, the resistance will be approximately 120 ohms.

To replace the assembly:

a. Remove the four screws holding the RF OUTPUT connector to the front panel.

b. Release attenuator cable from under cable clamp.

c. Remove mounting screw which holds the rack to the aluminum block on the attenuator probe.

d. Lift mounting block and probe from the circular waveguide housing.

e. Use care in handling attenuator probes. The glass rod resistor can be broken by twisting the cable.

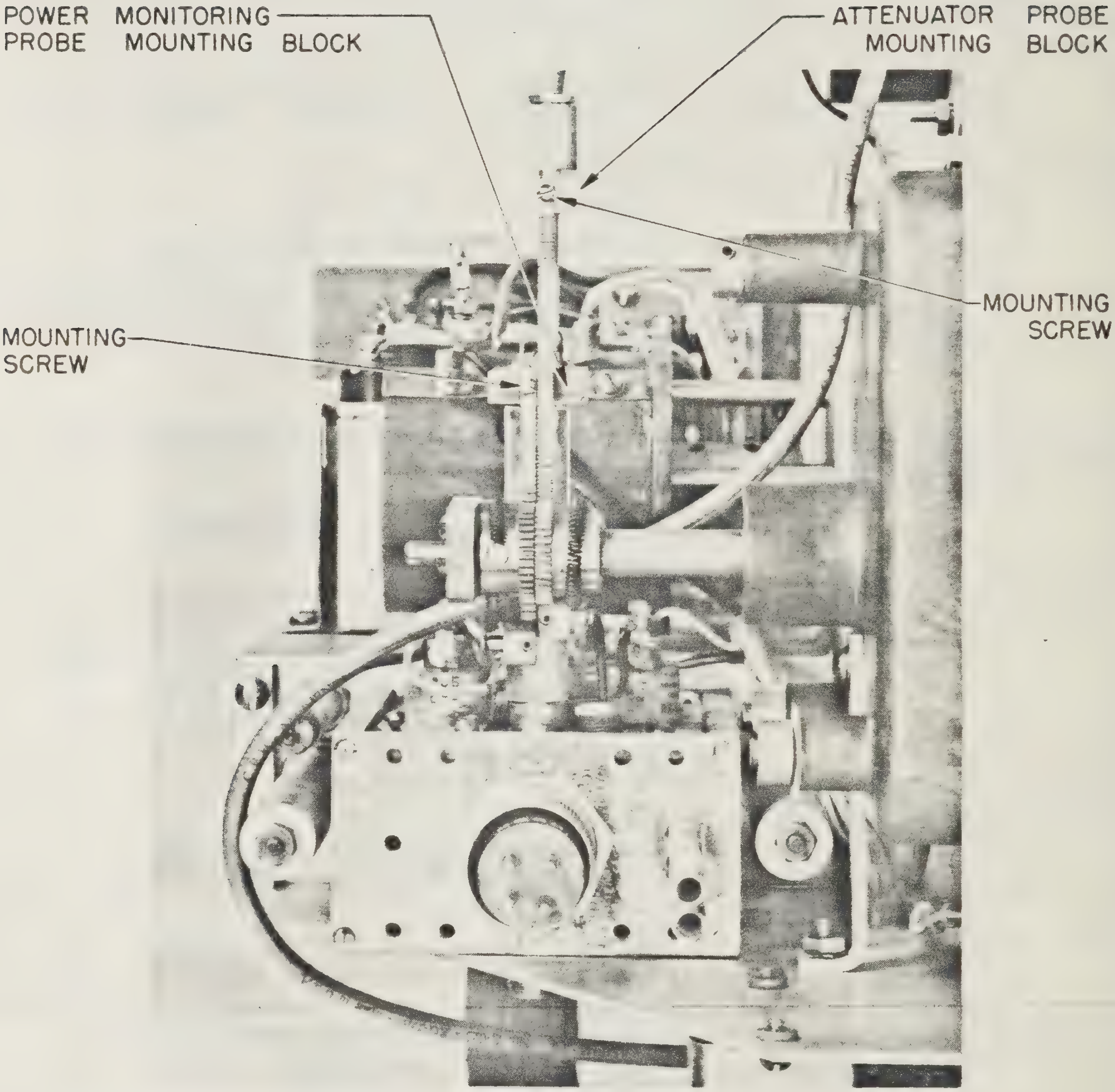


FIG. 4-3b ATTENUATOR AND POWER MONITORING PROBE DRIVE ASSEMBLY

f. Insert new probe into the waveguide only as far as is necessary to match up the mounting holes. Insert mounting screw and tighten.

g. Carefully thread cable under cable clamp and around casting to front panel. Avoid twisting cable more than one-quarter turn.

h. Remount RF OUTPUT connector. Tighten cable clamp.

i. After the assembly is replaced, an error of a few decibels may exist in the calibration of the attenuator dial. If desired, the calibration can be checked in accordance with paragraph 4-16 below.

4-16 RECALIBRATION OF THE ATTENUATOR DIAL

The following equipment will be required for this operation:

1. Hewlett-Packard Detector Mounts G485B and J485B or equivalents.

2. Hewlett-Packard Waveguide to Coax Adaptors G281A and J281A or equivalents.

3. Hewlett-Packard Power Meter 430B or equivalent.

To calibrate the attenuator dial:

a. Turn on the signal generator and allow to warm up for at least twenty minutes with the MOD SELECTOR switch in the CW position.

b. Place the MOD SELECTOR switch on OFF.

c. Adjust the ZERO SET control so that the needle of the POWER SET meter is on the ZERO SET line. Also adjust the zero set control on the 430B Power Meter for zero meter reading.

> Note. The time taken for zero set adjustments should be as short as possible (10 to 15 seconds) to reduce drift due to ambient temperature change.

d. Place the MOD SELECTOR switch in the CW position.

e. Tune signal generator to 3800 megacycles.

f. Adjust the POWER SET control so that the POWER SET meter reads 0 dbm (red line at midscale).

g. Adjust the Detector Mount G485B for maximum reading on the -5 range of the 430 Power Meter.

h. Adjust the OUTPUT ATTEN control to give a -7 dbm output.

i. Record reading of the 430 Power Meter.

j. Repeat steps b to i every 200 megacycles from 3800 to 7600 each time using same OUTPUT ATTEN dial setting. It will be necessary to change to J485B Detector Mount and J281A Adaptor for frequencies above 5850 mc.

k. Plot the data recorded on a graph, db vs frequency.

l. Draw a curve of the data to form a response curve for the signal generator. A typical curve thus obtained should consist of a series of peaks and troughs having a maximum range of ±1-1/4 db.

m. Draw a line through the curve so that the variations are averaged about the line.

n. Select a frequency where the curve intersects the average line. Tune signal generator to this frequency.

o. Tune detector mount for maximum reading on the 430 Power Meter.

p. With the MOD SELECTOR switch on OFF, zero set both meters.

q. With the MOD SELECTOR switch on CW, adjust the POWER LEVEL meter to 0 dbm.

r. Adjust the OUTPUT ATTEN control until the 430 Power Meter indicates -7 dbm. Lock control.

s. If attenuator dial does not now read -7 dbm, remove plate covering hub of dial. Loosen the set screws holding attenuator dial to shaft and slip dial to read -7 dbm. Tighten set screws.

t. The adjustment is complete when the power meter reads -7 dbm and the OUTPUT ATTEN dial reads -7 dbm when the signal generator is tuned to the frequency determined in step n.

4-17 POWER MOUNTING PROBE ASSEMBLY

The power level within the resonator is sampled by an assembly consisting of the power monitoring probe, an open bead type thermistor at its tip, and the probe mounting block and terminals. The assembly will normally last the life of the equipment. However, in the event that replacemnet becomes necessary, the following procedure should be employed:

a. Remove attenuator probe as explained in paragraph 4-15, b through e.

b. Disconnect the fine black and white leads that are soldered to the terminals on the power monitoring probe mounting block.

c. Remove screw holding mounting block to end of rack gear.

d. Withdraw probe from circular Waveguide housing.

e. Insert new probe only as far as is necessary to line up mounting holes. It is important that the replacement probe not be inserted too far into the waveguide housing.

f. Install mounting screw and tighten.

g. Solder black lead to terminal which is connected to shell of probe.

h. Solder white wire to terminal which is connected to the center conductor of the probe.

i. Install attenuator as instructed in paragraph 4-15 f to i.

Upon installation of a new power monitoring probe the calibration of the attenuator dial will usually be inaccurate, necessitating recalibration of this dial in accordance with paragraph 4-16.

4-18. REPLACING REPELLER TRACKING POTENTIOMETER R-174

To replace potentiometer R-174 the front panel assembly must first be removed. This will require removal of the four type BNC connectors from the front panel, the nine leads connected to the terminal board under the cavity, and the klystron housing and socket. The panel assembly can then be safely drawn away from the rest of the instrument.

Following removal of the panel assembly proceed as follows:

a. Loosen the set screws holding potentiometer R-174 shaft in the coupler. Remove wires from terminals.

b. Remove the three screws holding the potentiometer to the casting and withdraw potentiometer.

c. Place the shaft of the new potentiometer in the coupler. Do not tighten the set screws.

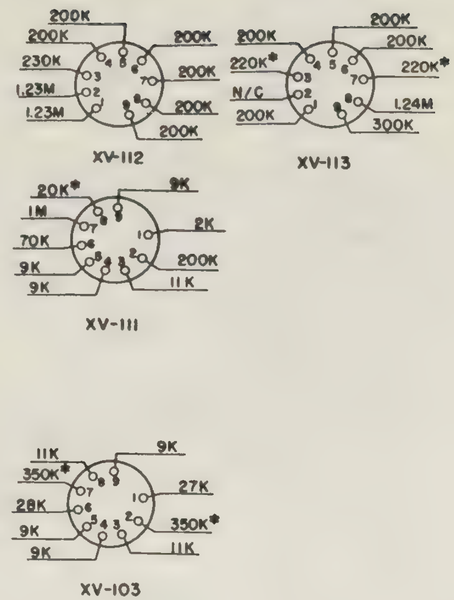
d. Position the potentiometer with the terminals near the top and replace the three mounting screws. Use care so that potentiometer shaft does not bind in coupler during any portion of rotation. Tighten mounting screws.

e. Turn the SIGNAL FREQUENCY control to one half turn from the low frequency end of the range of the signal generator.

f. Adjust the potentiometer arm so that it is just at the end of the potentiometer resistance wire.

g. Tighten set screws in the coupler.

h. Reset repeller voltage adjustments as described in paragraph 4-8, f through o.



NOTE:

EQUIPMENT DISCONNECTED FROM AC SOURCE

K = 1000 OHMS.

M = MEGOHMS

MEASUREMENTS MADE WITH SIMPSON MODEL 260 VOLT-OHM METER OR EQUIVALENT, USING SCALE THAT GIVES READING CLOSEST TO CENTER OF SCALE, REFERENCE TO GROUND, OR CHASSIS.

* THESE VALUES WILL VARY WITH THE SETTINGS OF THE FRONT PANEL CONTROLS.

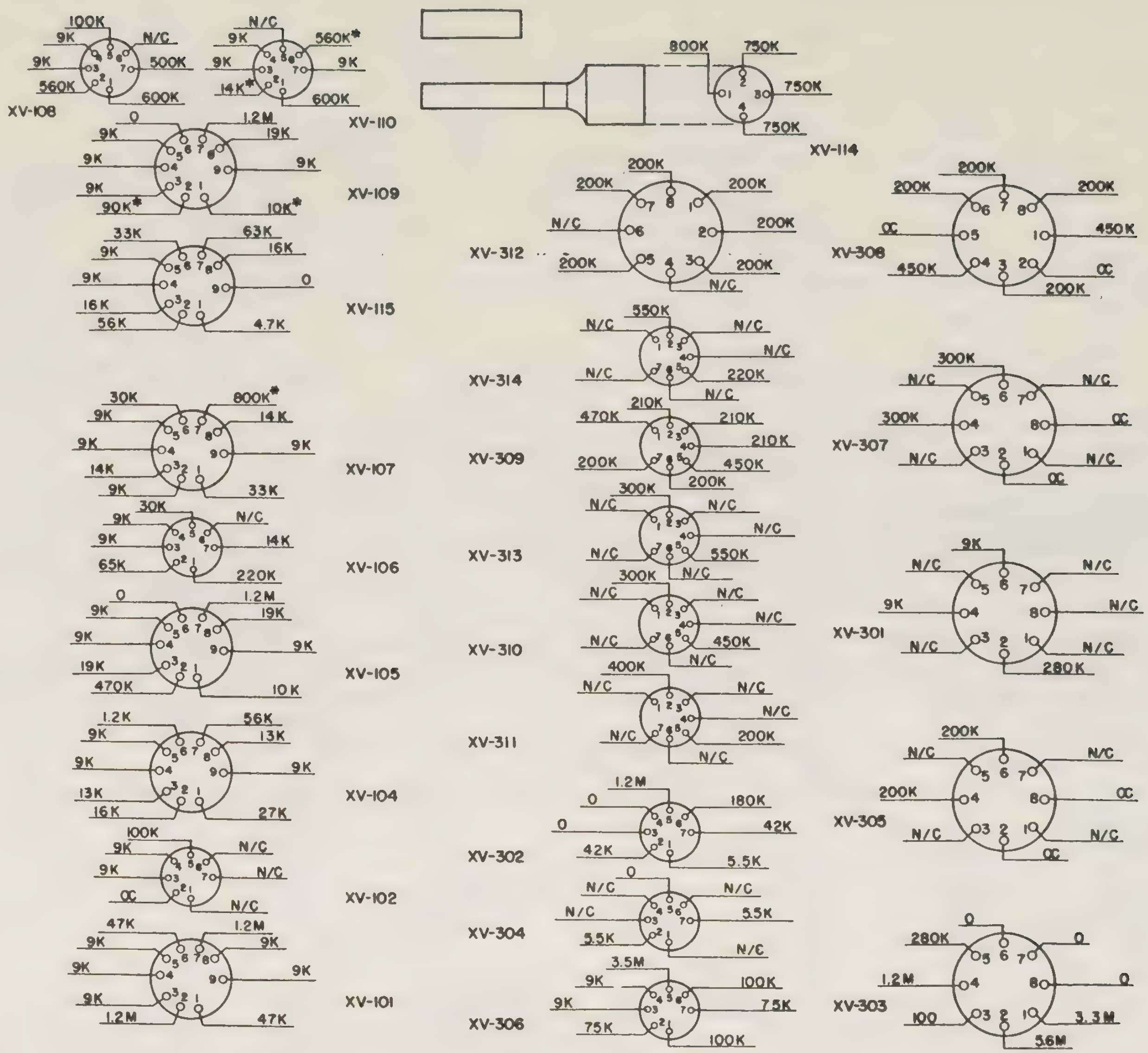
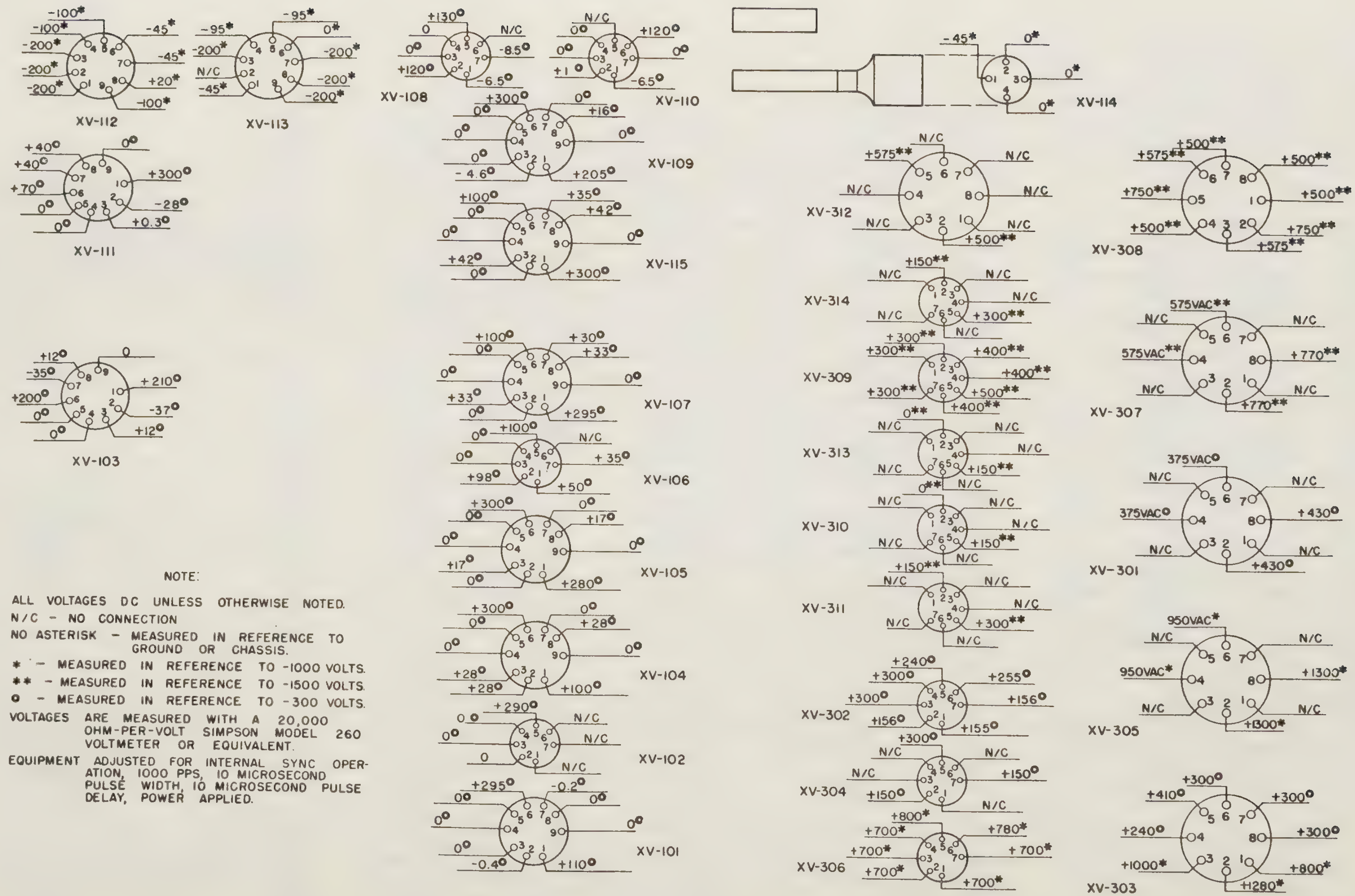


FIG. 4-4 TUBE SOCKET RESISTANCE MEASUREMENTS



NOTE:

ALL VOLTAGES DC UNLESS OTHERWISE NOTED.

N/C - NO CONNECTION

NO ASTERISK - MEASURED IN REFERENCE TO GROUND OR CHASSIS.

* - MEASURED IN REFERENCE TO -1000 VOLTS.

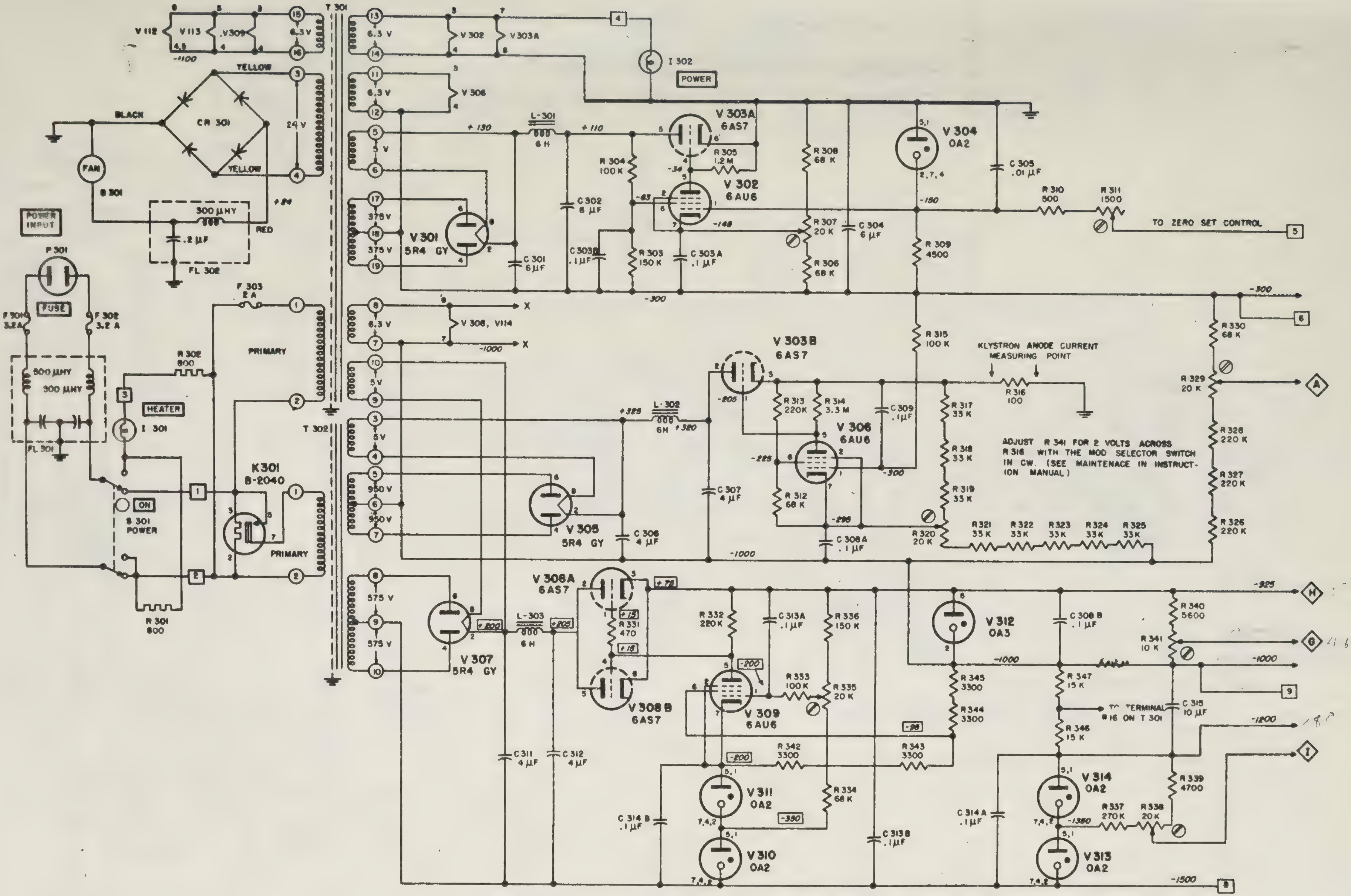
** - MEASURED IN REFERENCE TO -1500 VOLTS.

o - MEASURED IN REFERENCE TO -300 VOLTS.

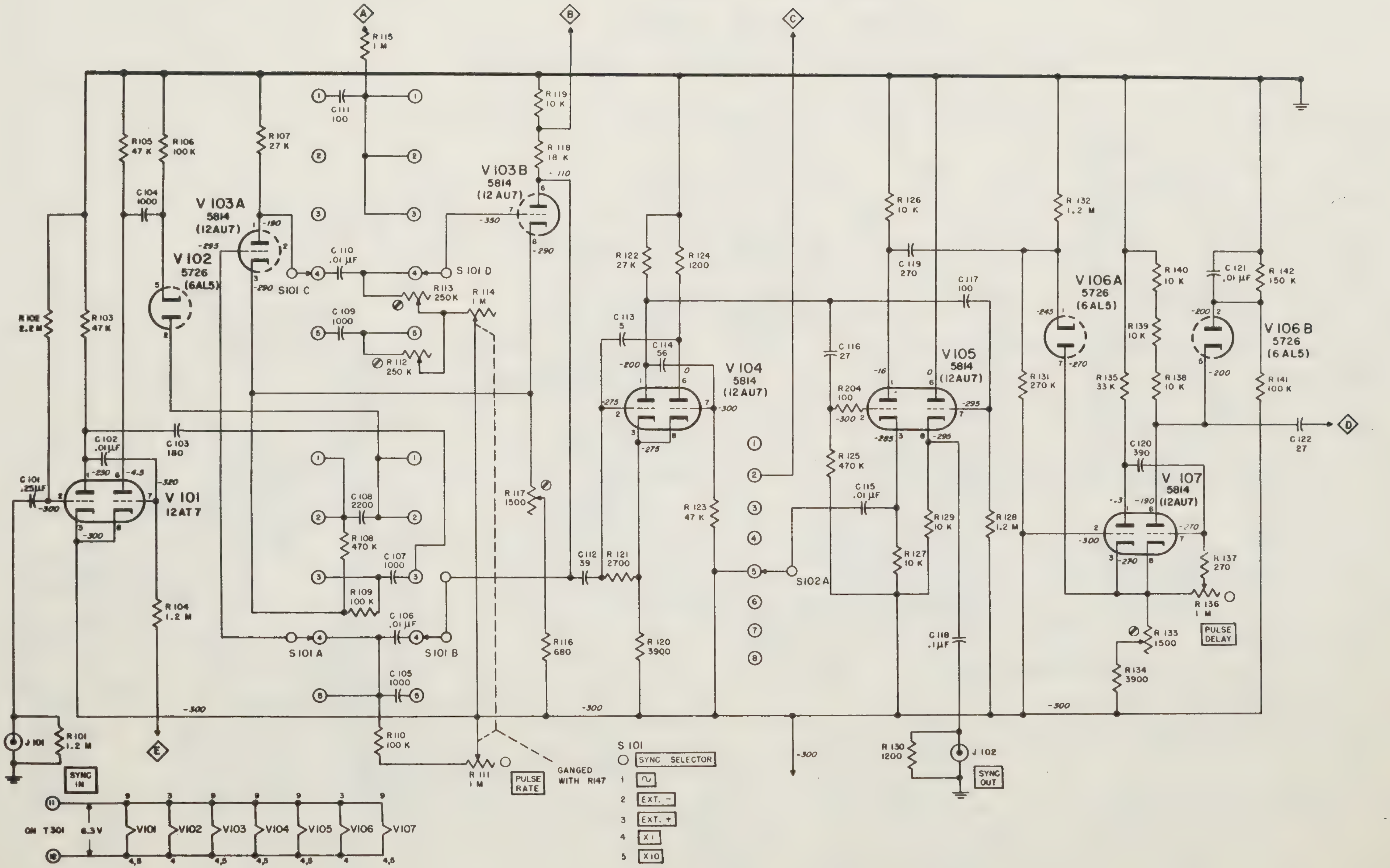
VOLTAGES ARE MEASURED WITH A 20,000 OHM-PER-VOLT SIMPSON MODEL 260 VOLTMETER OR EQUIVALENT.

EQUIPMENT ADJUSTED FOR INTERNAL SYNC OPERATION, 1000 PPS, 10 MICROSECOND PULSE WIDTH, 10 MICROSECOND PULSE DELAY, POWER APPLIED.

FIG. 4-5 TUBE SOCKET VOLTAGE MEASUREMENTS



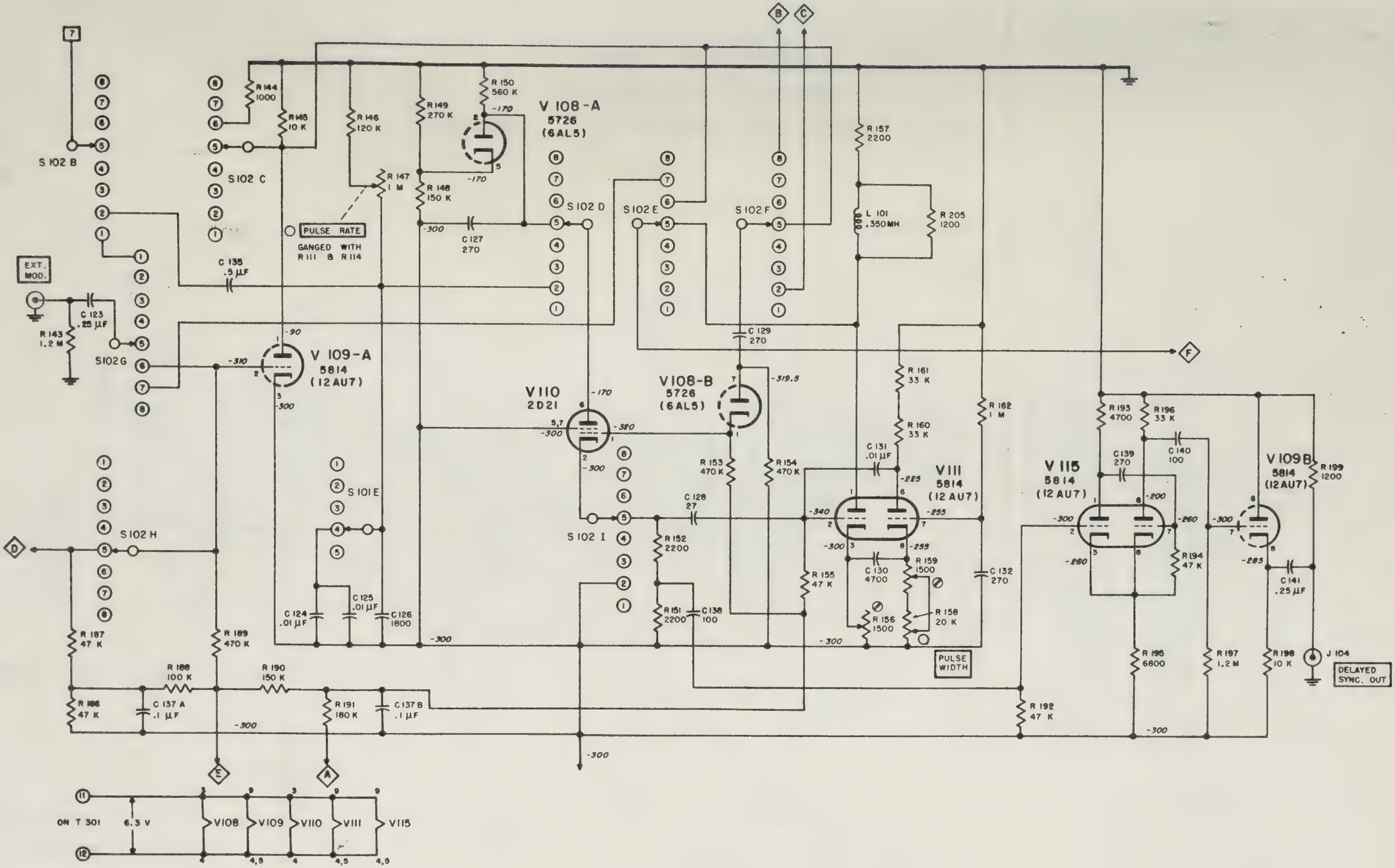
SCHEMATIC DIAGRAM OF MODEL 618 B
POWER SUPPLY SECTION
SERIAL 1 & ABOVE



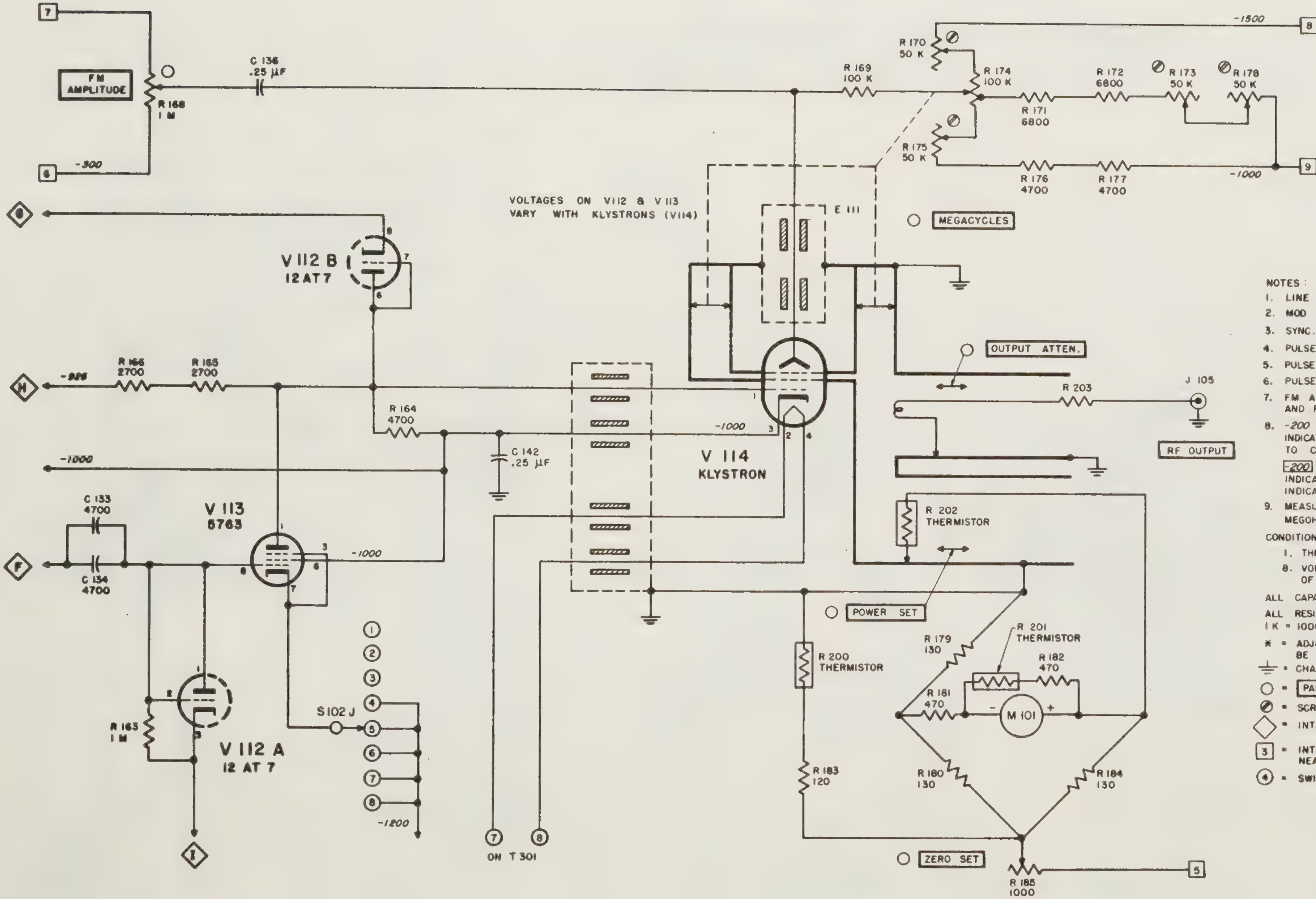
SCHEMATIC DIAGRAM OF MODEL 618 B

MODULATOR SECTION (PART 1)

SERIAL 1 & ABOVE



SCHEMATIC DIAGRAM OF MODEL 618 B
MODULATOR SECTION (PART 2)
SERIAL 1 & ABOVE



S 102 POSITION	PANEL DESIGNATION
1	EXT. FM
2	INT. FM
3	C W
4	OFF
5	INT.
6	EXT. +
7	EXT. -
8	SQ. WAVE

NOTES:

1. LINE VOLTAGE AT 115 VOLTS, 50/60 ∿
2. MOD SELECTOR SWITCH ON INT.
3. SYNC. SELECTOR ON X1
4. PULSE WIDTH ON 10
5. PULSE DELAY ON 10
6. PULSE RATE ON 100
7. FM AMPLITUDE, OUTPUT ATTEN., POWER SET, ZERO SET, AND FREQUENCY ARE NOT CRITICAL.
8. *-200* VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND CHASSIS. POLARITY INDICATED WITH RESPECT TO CHASSIS.

   $\boxed{-200}$ VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND THE -1000 VOLT SUPPLY. POLARITY INDICATED WITH RESPECT TO -1000 VOLT SUPPLY.
9. MEASUREMENTS MADE WITH A VACUUM TUBE VOLTMETER WITH 122 MEGOHMS INPUT RESISTANCE. (HP MODEL 410B)

CONDITIONS OF AC VOLTAGE MEASUREMENT:

1. THRU 7. SAME AS DC CONDITIONS.
8. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A METER OF 1000 OHMS/VOLT OR GREATER SENSITIVITY.

ALL CAPACITANCE VALUES IN µµF UNLESS OTHERWISE NOTED.
ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED,
1 K = 1000 OHMS, 1 M = 1 MEGOHM

* = ADJUSTED AT FACTORY, AVERAGE VALUE SHOWN, PART MAY BE OMITTED.
⏚ = CHASSIS
○ = PANEL CONTROL
⊘ = SCREWDRIVER ADJUSTMENT
◇ = INTERCONNECTION BETWEEN SECTIONS OF SCHEMATIC DIAGRAM.
$\boxed{3}$ = INTERCONNECTIONS LOCATED ON TERMINAL BOARD BEHIND PANEL NEAR PILOT LIGHTS.
④ = SWITCH POSITIONS OR TRANSFORMER TERMINALS.

SCHEMATIC DIAGRAM OF MODEL 618 B
KLYSTRON SECTION
SERIAL 1 & ABOVE

LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

Code Letter	Manufacturer
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
HP	Hewlett-Packard
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Hi-Q Division of Aerovox Corp.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
V	Micamold Radio Corp.
X	P.R. Mallory Co., Inc.
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
HH	Amphenol
II	Dial Light Co. of America
KK	Switchcraft, Inc.
LL	Gremar Mfg. Co.
MM	Carad Corp.
ZZ	Any tube having RETMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof (except tubes, fuses and batteries). This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number, type number and serial number. On receipt of this information, we will give you service instruction or shipping data.

2. On receipt of shipping instruction, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

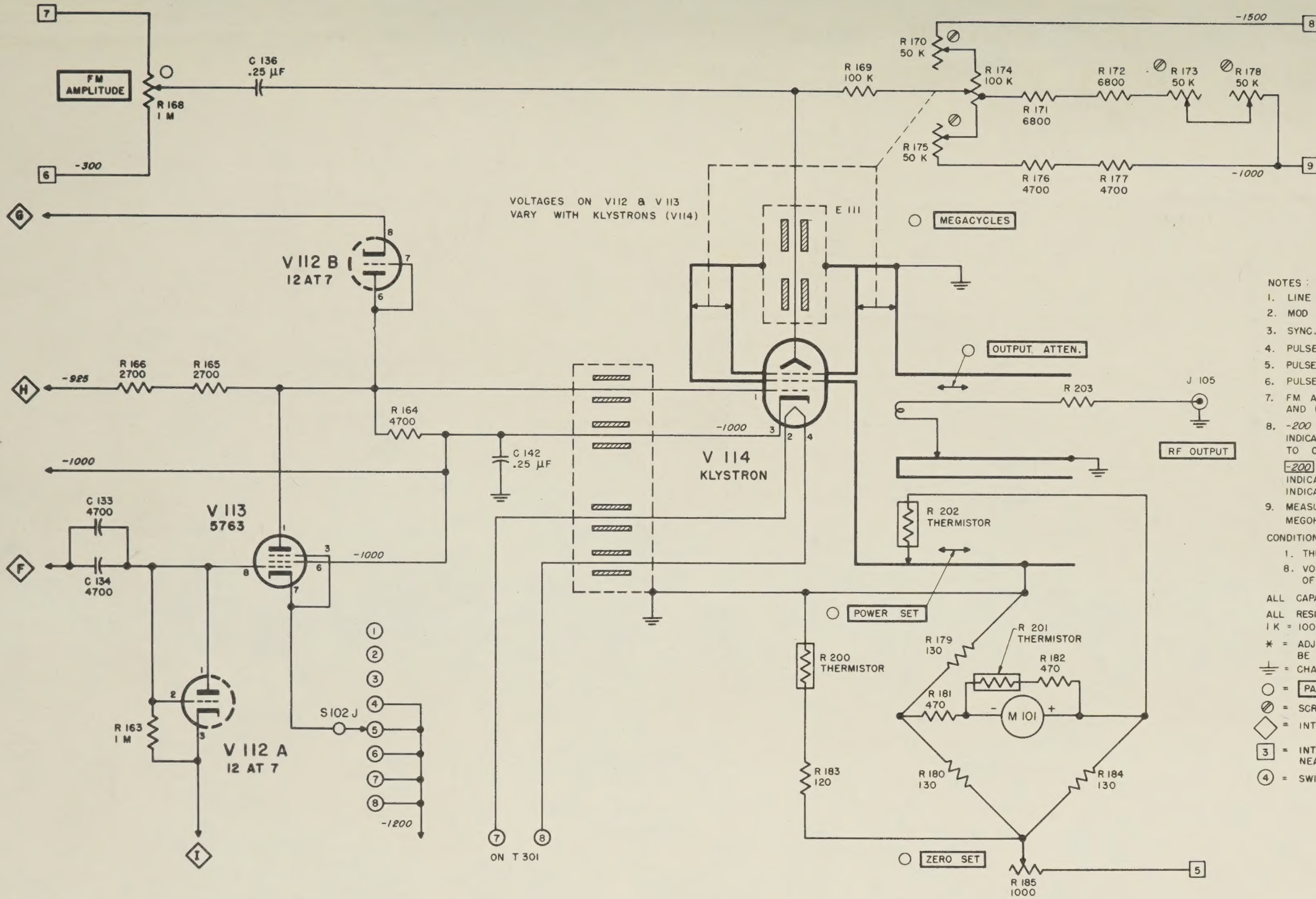
All shipments of Hewlett-Packard instruments should be made via Railway Express. The instruments should be packed in a wooden box and surrounded by two to three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY

Laboratory Instruments for Speed and Accuracy

395 PAGE MILL ROAD hp PALO ALTO, CALIFORNIA



S 102 POSITION	PANEL DESIGNATION
1	EXT. FM
2	INT. FM
3	C W
4	OFF
5	INT.
6	EXT. +
7	EXT. -
8	SQ. WAVE

NOTES :

1. LINE VOLTAGE AT 115 VOLTS, 50/60 ∿
2. MOD SELECTOR SWITCH ON INT.
3. SYNC. SELECTOR ON X1
4. PULSE WIDTH ON 10
5. PULSE DELAY ON 10
6. PULSE RATE ON 100
7. FM AMPLITUDE, OUTPUT ATTEN., POWER SET, ZERO SET, AND FREQUENCY ARE NOT CRITICAL.
8. *-200* VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND CHASSIS. POLARITY INDICATED WITH RESPECT TO CHASSIS.

   $\boxed{-200}$ VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND THE -1000 VOLT SUPPLY. POLARITY INDICATED WITH RESPECT TO -1000 VOLT SUPPLY.
9. MEASUREMENTS MADE WITH A VACUUM TUBE VOLTMETER WITH 122 MEGOHMS INPUT RESISTANCE. (HP MODEL 410B)

CONDITIONS OF AC VOLTAGE MEASUREMENT :

1. THRU 7. SAME AS DC CONDITIONS.
8. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A METER OF 1000 OHMS / VOLT OR GREATER SENSITIVITY.

ALL CAPACITANCE VALUES IN µµF UNLESS OTHERWISE NOTED.

ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED, 1 K = 1000 OHMS, 1 M = 1 MEGOHM.

* = ADJUSTED AT FACTORY, AVERAGE VALUE SHOWN, PART MAY BE OMITTED.

⏚ = CHASSIS

○ = PANEL CONTROL

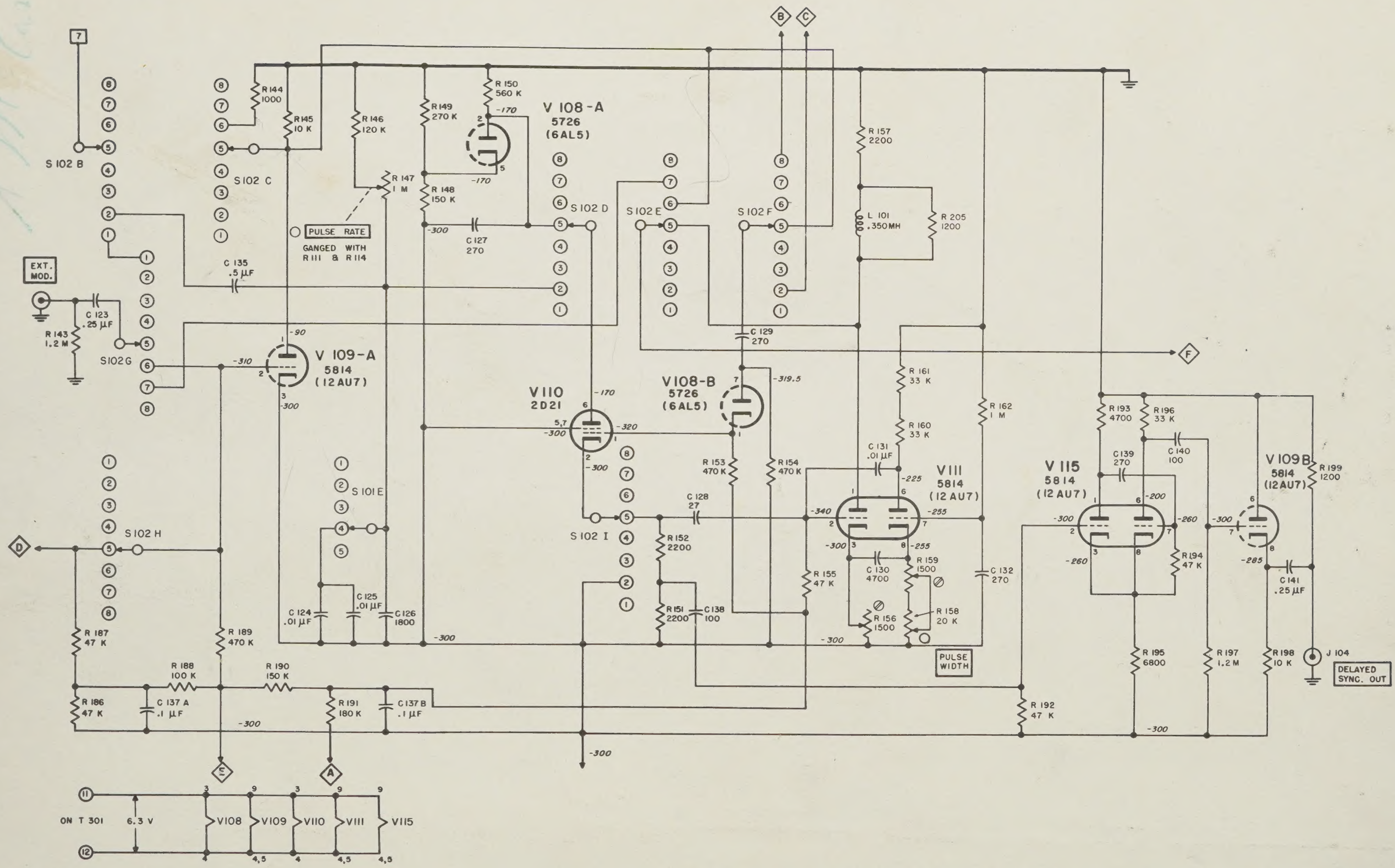
⊘ = SCREWDRIVER ADJUSTMENT

◇ = INTERCONNECTION BETWEEN SECTIONS OF SCHEMATIC DIAGRAM.

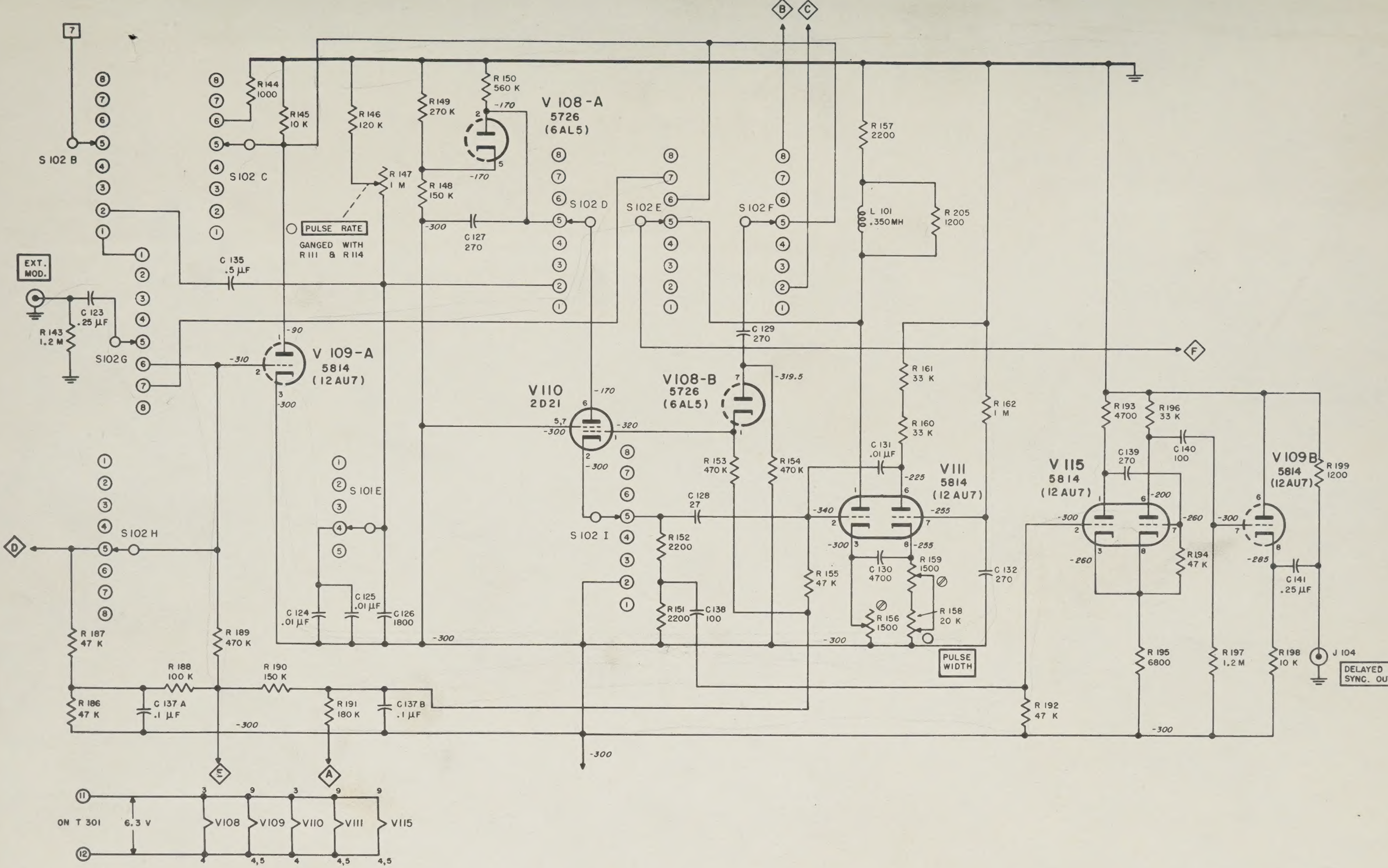
$\boxed{3}$ = INTERCONNECTIONS LOCATED ON TERMINAL BOARD BEHIND PANEL NEAR PILOT LIGHTS.

④ = SWITCH POSITIONS OR TRANSFORMER TERMINALS.

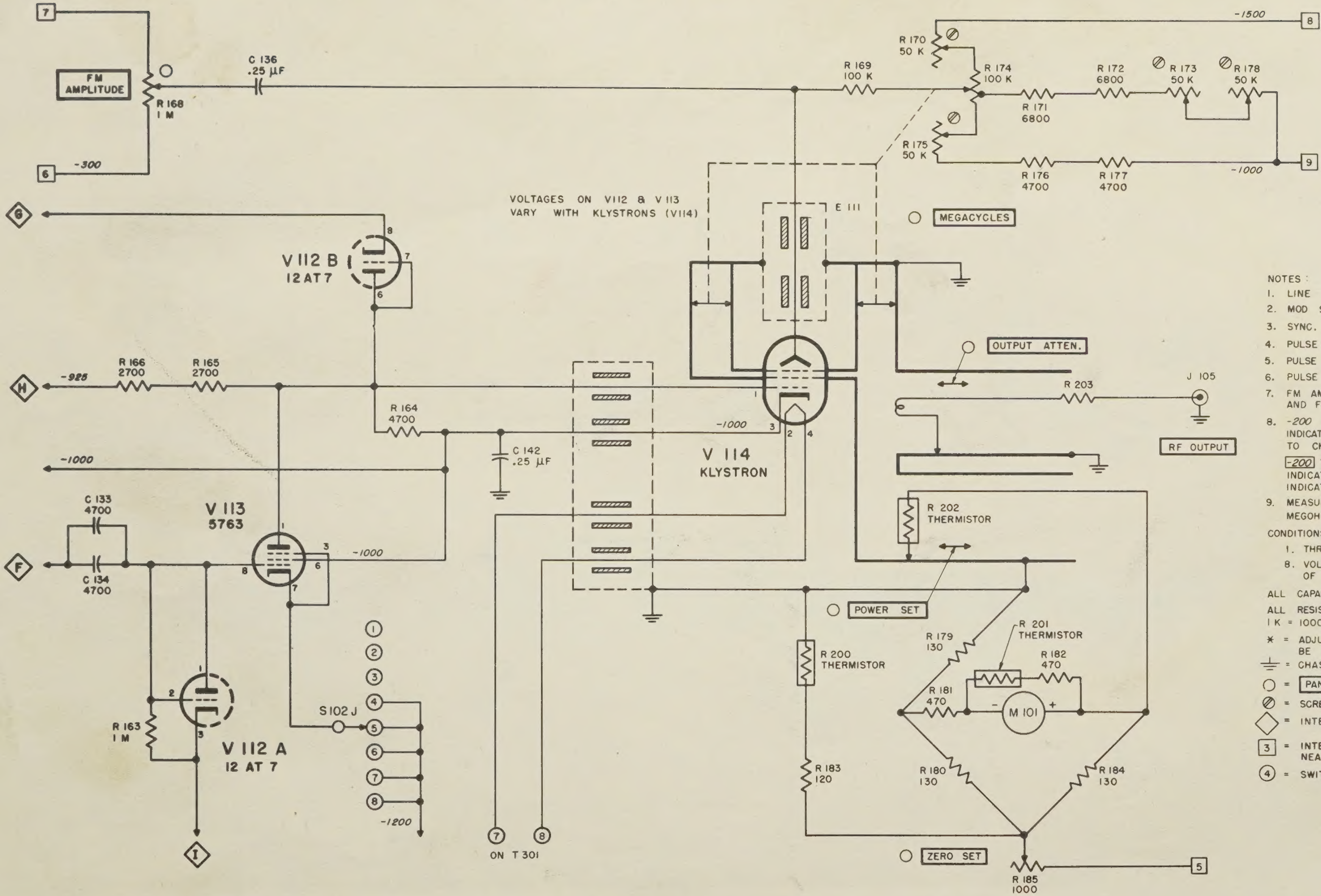
SCHEMATIC DIAGRAM OF MODEL 618 B
KLYSTRON SECTION
SERIAL 1 & ABOVE



SCHEMATIC DIAGRAM OF MODEL 618 B
MODULATOR SECTION (PART 2)
SERIAL 1 & ABOVE



SCHEMATIC DIAGRAM OF MODEL 618 B
MODULATOR SECTION (PART 2)
SERIAL 1 & ABOVE



S 102 POSITION	PANEL DESIGNATION
1	EXT. FM
2	INT. FM
3	C W
4	OFF
5	INT.
6	EXT. +
7	EXT. −
8	SQ. WAVE

NOTES :

1. LINE VOLTAGE AT 115 VOLTS, 50/60 ∿
2. MOD SELECTOR SWITCH ON INT.
3. SYNC. SELECTOR ON X1
4. PULSE WIDTH ON 10
5. PULSE DELAY ON 10
6. PULSE RATE ON 100
7. FM AMPLITUDE, OUTPUT ATTEN., POWER SET, ZERO SET, AND FREQUENCY ARE NOT CRITICAL.
8. *-200* VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND CHASSIS. POLARITY INDICATED WITH RESPECT TO CHASSIS.

   $\boxed{-200}$ VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND THE -1000 VOLT SUPPLY. POLARITY INDICATED WITH RESPECT TO -1000 VOLT SUPPLY.
9. MEASUREMENTS MADE WITH A VACUUM TUBE VOLTMETER WITH 122 MEGOHMS INPUT RESISTANCE. (HP MODEL 410B)

CONDITIONS OF AC VOLTAGE MEASUREMENT :

1. THRU 7. SAME AS DC CONDITIONS.
8. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A METER OF 1000 OHMS / VOLT OR GREATER SENSITIVITY.

ALL CAPACITANCE VALUES IN µµF UNLESS OTHERWISE NOTED.

ALL RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED, 1 K = 1000 OHMS, 1 M = 1 MEGOHM.

* = ADJUSTED AT FACTORY, AVERAGE VALUE SHOWN, PART MAY BE OMITTED.

⏚ = CHASSIS

○ = PANEL CONTROL

⊘ = SCREWDRIVER ADJUSTMENT

◇ = INTERCONNECTION BETWEEN SECTIONS OF SCHEMATIC DIAGRAM.

$\boxed{3}$ = INTERCONNECTIONS LOCATED ON TERMINAL BOARD BEHIND PANEL NEAR PILOT LIGHTS.

④ = SWITCH POSITIONS OR TRANSFORMER TERMINALS.

SCHEMATIC DIAGRAM OF MODEL 618 B

KLYSTRON SECTION

SERIAL 1 & ABOVE